HAWAII OCEAN RESOURCES MANAGEMENT PLAN

TECHNICAL SUPPLEMENT

HAWAII OCEAN AND MARINE
RESOURCES COUNCIL

JANUARY 1991

PREFACE

The Hawaii Ocean Resources Management Plan sets forth guiding principles and overall recommendations for the State to achieve comprehensive and integrated ocean and coastal resources management. The Plan is based on major public input involving over 900 individuals statewide. The Plan was mandated by Chapter 228, Hawaii Revised Statutes, and developed by the Hawaii Ocean and Marine Resources Council.

The Technical Supplement provides detailed analyses and survey results that are the foundation of the Plan. In particular, the policies, implementing actions and overall recommendations contained within the Plan were derived from the technical papers published here. The Technical Supplement and the Plan were prepared by the same planning team.

The Technical Supplement is the most comprehensive reference available on the current status and assessment of ocean and coastal resources management in Hawaii. The technical papers presented in this document were developed with the assistance of 170 subject-matter experts and community leaders. These individuals participated in ten facilitated workshops for the specific resource sectors considered or otherwise provided critical input. Nine State departments worked cooperatively to complete the survey of Hawaii's ocean and coastal programs for the fiscal period 1988-1991. The survey results are reported in their entirety here.

Readers using the Technical Supplement should find the keyword index helpful when searching for themes or issues that cut across sector-specific subject areas. The individual technical papers should be consulted directly for those readers interested in specific resource sectors. Those with an eye towards program structure and budget allocation should refer to the summary matrices in the Appendices.

How the Technical Supplement is used, will be a matter of need and purpose. The important emphasis here is on the action-word "use". This document is intended to be used to help State government implement the Plan. The Plan is intended to be used to strengthen the management of Hawaii's ocean and coastal resources. Together, the Hawaii Ocean Resources Management Plan and the Technical Supplement are important tools. They now need to be applied with commitment and in earnest.

HAWAII OCEAN AND MARINE RESOURCES COUNCIL

The Council is composed of eleven voting members, including six ex-officio members and five members appointed by the Governor to represent commercial, recreational, environmental and research interests. The Council members are:

Roger A. Ulveling, Chairperson
Director, Department of Business,
Economic Development &Tourism

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Deputy Director, Office of State Planning

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J. Dave Raney
(environmental interest)

Richard S. Shomura
(research interest)

Council Staff:

Craig D. MacDonald, Project Manager
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PLANNING TEAM

The following individuals made up the technical team responsible for developing the Hawaii Ocean Resources Management Plan and Technical Supplement for the Hawaii Ocean and Marine Resources Council. Team members were from the Department of Business, Economic Development & Tourism; the University of Hawaii Department of Urban and Regional Planning, Social Science Research Institute, William S. Richardson School of Law, and Sea Grant Extension Service; the State Judiciary Center for Alternative Dispute Resolution; and the private sector.

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TECHNICAL PAPERS

The technical papers presented in this section are based on extensive review of published documents and numerous interviews with relevant government, industry and research experts. In addition, ten facilitated workshops were held to collect feedback on drafts of the papers from 170 subject-matter experts and community leaders statewide. The final policies and recommended actions for each sector paper were then submitted to the Council for their review and revision.

Each technical paper describes the existing resource or activity, reviews related Federal, State and County regulatory regimes, and identifies current management issues. Each paper concludes with a statement of the management objective and a list of policies and implementing actions responding to the issues identified. The policies and actions presented in this section are the revised versions approved by the Council.

The Council did not attempt to set priorities among these policies and actions, nor had sufficient time to determine if they were mutually exclusive or in conflict with one another. It would become the responsibility of the Office of Marine and Coastal Affairs, proposed by the Council in the Hawaii Ocean Resources Management Plan, to evaluate and prioritize the policies and actions in conjunction with the designated agencies.

The following is a list of the sector-specific technical papers in the order in which they appear in this section:

- Ocean Research and Education
- Ocean Recreation
- Harbors
- Fisheries
- Marine Ecosystem Protection
- Beaches and Coastal Erosion
- Waste Management
- Aquaculture
- Energy
- Marine Minerals

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OCEAN RESEARCH AND EDUCATION

Ocean research and education will be major determinants of the long-term success of the *Hawaii Ocean Resources Management Plan.* The public has to understand the need for the Plan and why the policies and recommendations are proposed, in order to give its support. A marine-literate public is most likely to embrace the guiding principles of conservation and integrated management and collectively act as responsible stewards of Hawaii's ocean and coastal resources.

In the most general terms, research is the acquisition of knowledge; education is the conveyance of knowledge. Each derives from the other in cyclical fashion such that research and education are functionally related. This interrelationship is most frequently reflected in the organization of our higher academic institutions.

As a practical matter of resource management, the two sets of activities are more discrete. Each is associated with its own set of impacts and issues requiring separate policies and actions; each is associated with its own set of constituencies. This general dichotomy is reflected in the following treatment of ocean research and education in Hawaii.

While most of the research and education activities in Hawaii are centered on Oahu, this sector plan has broad relevance statewide. New marine resource centers and research facilities are being established on or are planned for the Neighbor Islands. Neighbor Island populations are increasing, and there is greater demand and need for more broadly distributing the benefits derived from such programs.

THE RESOURCE[1]

The Hawaiian Islands are an unequalled natural laboratory for ocean research and education. Research professionals and educators from many countries pursue a multitude of projects year-round here. And, Hawaii's public schools and resource centers have formal programs in marine education that have the potential to rival similar such programs anywhere.

The volcanic origin of the Islands and the absence of a continental shelf give immediate access to an abundance of

ocean resources from warm surface waters to the cold deep seafloor. Untouched coral reefs and deep ocean seamounts are near at hand as are a wide range of intermediate habitat types. Even an active underwater volcano, Loihi, lies within a day's sail of the Big Island. Hawaii's tidal benches and reef flats are excellent field laboratories for general education. There is lack of neither potential research sites nor educational opportunities.

Complementing Hawaii's rich natural resource base are superior support facilities and personnel. Researchers perform competitively here, drawing upon an extensive infrastructure for such services as satellite communications and tracking, electronics design and maintenance, engineering design and manufacturing, marine laboratory analyses, marine surveying and brokering, and ship maintenance, dry-docking and supply. The University of Hawaii is recognized nationally and internationally for its distinguished ocean faculty, and its solid offering of marine programs is a strong draw for students from around the world. Dedicated marine professionals staff Hawaii's educational and public information institutions statewide.

Hawaii enjoys one of the strongest institutional infrastructures in the country in support of ocean research and education. To mention just a few, the U.S. Navy operates a major branch of its Naval Ocean Systems Center here. The University of Hawaii administers the School of Ocean and Earth Science and Technology. The Law of the Sea Institute resides in Hawaii. And there are several national ocean research centers here such as, the Marine Minerals Technology Center (U.S. Department of the Interior), the Pacific Mapping Center (U.S. Departments of Commerce and Interior jointly) and the Center for Tropical and Subtropical Aquaculture (U.S. Department of Agriculture), that provide support for a range of academic and commercial activities. The list is equally long for general educational organizations offering marine-related courses and public information.

With a powerful combination of natural, physical and human resources, research and education in Hawaii takes place in virtually every ocean-related field, including: aquaculture, biology, energy, engineering, fisheries, geophysics, law and policy, mining and minerals, oceanography, recreation, resource economics, surveying and mapping, transportation and water quality. Hawaii enjoys strategic advantages in many of these areas, and is attracting increasing attention as opportunities afforded by Hawaii's Exclusive Economic Zone (EEZ) become recognized.

Ocean Research and Development

Among Hawaii's ocean industries, ocean research and development (R&D) is growing rapidly in importance (MacDonald and LaBarge 1990). The research includes both basic and applied. Ocean R&D revenues in Hawaii were $62 million in 1989, having grown at 13 percent per year since 1980, and direct employment was about 1,500. The total employment impact resulting from these revenues is twice this number. The major performers of this work and the research funds received were: private businesses ($16.7 million), Federal agencies ($16.3 million), the University of Hawaii ($16.0 million), and nonprofit organizations ($11.4 million). This amounts to 98 percent of the total ocean R&D revenues for that year.

Ocean R&D in Hawaii is heavily supported by the Federal government, which provided 83 percent of the revenues between 1980 and 1989. All of the major performers in Hawaii rely heavily on Federal sources for research revenues: Federal agencies (100 percent), University of Hawaii (88 percent), private businesses (69 percent) and nonprofit organizations (68 percent). Ninety percent of these funds come from three principal agencies: U.S. Navy, U.S. Department of Commerce - National Oceanic and Atmospheric Administration and the National Science Foundation (Gopalakrishnan and Sisson 1987; MacDonald et al 1990). Hawaii ranks high nationally in terms of Federal receipts of ocean R&D dollars.

Ocean R&D revenues for the decade (1980-1989) in Hawaii were $395 million (MacDonald and LaBarge 1990). The total economic impact of these revenues was about half a billion dollars. Projected revenues for the industry in 1996 range between $87 and $147 million. Although Federal support is expected to continue fueling growth, foreign spending for ocean R&D in Hawaii (primarily from Japan and Singapore) is increasing. The outlook for ocean R&D in Hawaii is favorable but management of emerging issues will need to be carefully considered to accommodate further expansion and ensure continued growth and economic viability.

Marine Education

Hawaii's ocean is a stimulating place to study and learn and offers exciting opportunities for experiential education. Marine education as a profession is also a significant source of employment. Course offerings and informational seminars on ocean-related topics are numerous and diverse and are provided by a broad spectrum of organizations (e.g., Federal, State and County government agencies, nonprofit organizations and businesses).

The possibilities for pursuing formal education in marine-related fields in Hawaii are exceptional. At the University of Hawaii at Manoa, seven colleges, five schools plus one major interdisciplinary program offer a total of 205 marine-related courses (UH 1989). All University of Hawaii campuses, including community colleges (except West Oahu), offer at least one such course. So do Brigham Young University, Chaminade University and Hawaii Pacific University. Hawaii Loa University has an undergraduate degree program in marine science. The East-West Center offers fellowships for foreign students to pursue graduate degrees in ocean-related work.

The State Department of Education (DOE) introduces public school students (K-12) to the ocean through formal classwork and field trips. An expanded marine science program for elementary and secondary schools is proposed (Hawaii

Natural Energy Institute, 1990). "At-sea" learning experience is provided to students through the Blue Water Marine Laboratory Program administered by the Waikiki Aquarium in cooperation with DOE. The Hawaiian Academy of Science assists DOE in conducting the annual Student Symposium on Marine Affairs. The Hawaii State Teachers Association conducts supplemental marine science workshops and field trips for its members. DOE also works cooperatively with other marine-related organizations and agencies that provide enrichment/complementary learning opportunities.

The marine education needs of a wider segment of Hawaii's population are being met by an equally diverse array of programs. The Waikiki Aquarium and Sea Life Park both have education departments that serve the general public of all ages from both the resident and visitor markets and provide extensive community outreach for residents. The Bishop Museum, Hawaii Maritime Center, Pacific Whale Foundation and Friends of Heeia State Park also serve a marine-related public education function. Additionally, Hawaii is host to numerous national and international conferences that promote marine research and education and is headquarters for PACON International (organizer of the biennial Pacific Congress on Marine Science and Technology) and the Pacific Science Association.

Public information on marine-related matters in Hawaii is provided by diverse Federal, State and County agencies such as: National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Coast Guard, State Departments of Health, Transportation and Land and Natural Resources, various County parks and recreation departments, and Richardson Ocean Center. Environmental organizations including Greenpeace, the Nature Conservancy, Sierra Club and Audubon Society also offer public information regarding Hawaii's marine resources. And, a growing number of visitor-oriented private businesses are incorporating information on marine resources in their tour packages.

RESOURCE MANAGEMENT

Regulation and Enforcement

Four sets of conditions generally apply to ocean research and education in Hawaii: 1) scientific collecting permit, 2) entry permits, 3) endangered species protection, and 4) water quality standards.

Scientific Collecting Permit

A Scientific Collecting Permit is required to take, possess or sell certain species of marine life using certain kinds of restricted gear or in restricted areas. The uses covered by this permit include scientific research and study and extend to endangered species under State law. Examples of restricted areas include Marine Life Conservation Districts, Underwater Parks, Fishery Management Areas, Natural Area Reserves, Wildlife Refuges and Sanctuaries, etc. The Scientific Collecting Permit is issued by the Division of Aquatic Resources, Department of Land and Natural Resources (DLNR). Compliance with this permit is enforced by the Department's Division of Conservation and Resources Enforcement (DOCARE).

Although a scientific collecting permit may not be required of field trips for educational purposes, State laws and administrative rules remain applicable. Minimum sizes, closed seasons, restricted area conditions, etc. apply. Collection with small nets (less than two inches across the "eye") requires an aquarium fish permit issued by DOCARE. Collection is prohibited in any Natural Area Reserve (e.g., Ahihi-Kinau) and Wildlife Sanctuary (e.g., Paiko Lagoon). Collection of endangered and threatened species, even for education purposes, is strictly prohibited by State (and Federal) law.

Entry Permits

Some of Hawaii's State wildlife refuges have an ocean component, such as the Kure Atoll Wildlife Refuge in the Northwestern Hawaiian Islands (NWHI). Entry clearance and permits detailing the proposed study plan are issued by the State Division of Forestry and Wildlife (DLNR). Permits can only be obtained for educational and scientific purposes of a nature that will not disturb wildlife occupying the refuge.

Access to Federal wildlife refuges, such as the Hawaiian Islands National Wildlife Refuge, which has an extensive ocean component, is restricted by authority granted through the Wildlife Refuge Administration Act. Entry is limited to approved research personnel and is by Special Use Permit issued by the Refuge Manager, U.S. Fish and Wildlife Service, in response to written requests outlining the specific research study plan. The Wildlife Refuge consists of most of the islands and lagoon and shoal waters located to the northwest of Kauai and Niihau and extends over an expanse of 1,600 km. Kure Atoll (State refuge as noted) and Midway Islands are not part of the refuge. Research logistics in the NWHI are complex, based in part upon management concerns (Dollar 1978).

Midway Islands are possessions of the United States administered under the jurisdiction of the U.S. Navy and are not legally part of the State of Hawaii. Midway is a defense installation and security clearance is required by the Secretary of the Navy. A letter of intent identifying the research project must be submitted including purpose, sponsoring agency and reasons why entrance to Midway is necessary. The Navy also maintains a Naval Defense at Sea Area, which encompasses all the waters within an 8-km boundary of Midway Islands. Research vessels are allowed to pass through this area with permission from the Navy.

U.S. Coast Guard approval is required for access to areas where it operates and maintains facilities, such as Molokini Islet. Research vessels towing or lowering gear in or near submarine transit lanes or the Barking Sands Missile Range are well advised to clear their activities with the military.

Endangered Species Protection

Federally funded or permitted research and educational activities that potentially would impact critical habitat of an endangered species require at least informal consultation under Section 7 of the Federal Endangered Species Act. If determination of adverse impact is found, formal consultation is required. Also, permits are required under this Act to conduct research

and education-related activities on all listed species, which otherwise cannot be disturbed, harassed or collected. Similar permits are required to conduct research and associated activities involving marine mammals pursuant to the federal Marine Mammals Protection Act. Consultation and permitting under both of these acts are conducted by the Pacific Area Office, National Marine Fisheries Service (NMFS).

By cooperative agreement, the NMFS shares jurisdiction and authority with the U.S. Fish and Wildlife Service (FWS) for management of marine turtles in Hawaii. Protection of endangered or threatened seabirds is provided by cooperative agreement between FWS and the DLNR's Division of Forestry and Wildlife under the Federal Migratory Bird Treaty Act. There is no similar cooperative agreement between NMFS and DLNR for protection of other marine endangered species. Such cooperative agreements are provided for under Section 6 of the Federal Endangered Species Act. Anyone conducting research or educational activities involving these species is required to seek approval from the respective agencies.

Water Quality Standards

For all State waters, standards for water quality established by the Department of Health (Chapter 11-54, HAR), must not be exceeded (directly or indirectly) by any research or educational activity. These standards pertain to activities on ships at sea as well as to activities at shore-based facilities such as the Waikiki Aquarium and Sea Life Park, Natural Energy Laboratory of Hawaii (NELH), and Hawaii Ocean Science and Technology (HOST) Park. The standards stipulate basic water quality criteria applicable to all waters which cover floating debris (especially plastics), thermal pollution, turbidity and nearly 100 toxic substances including radioactive isotopes.

Research and Education

Primary support for ocean research and associated academic affairs at the University of Hawaii at Manoa is provided by the School of Ocean and Earth Science and Technology. The School is composed of four departments (Oceanography, Geology and Geophysics, Meteorology and Ocean Engineering) and three research institutes (the Hawaii Institute of Geophysics, Hawaii Institute of Marine Biology and Hawaii Natural Energy Institute). The School administers three shared Federal/university research programs (the Joint Institute for Marine and Atmospheric Research, Hawaii Undersea Research Laboratory, and the Sea Grant College Program). The School administers the undergraduate Marine Option Program and the graduate Ocean Policy Certificate Program. It also administers the University Marine Center and is responsible for research vessel operations. Interdisciplinary divisions and centers within the school are being considered that can be more clearly identified with federally sponsored research programs (e.g. global climate change) than can the individual departments and institutes.

Other schools and colleges at the University of Hawaii having ocean-related course offerings and/or supporting graduate research in marine-related subjects include: the College of Arts and Humanities, College of Education, College of Engineering, College of Languages, Linguistics and Literature, School of Travel Industry Management, College of Natural Sciences, College of Social Sciences, College of Tropical Agriculture and Human Resources, School of Law, School of Medicine, School of Public Health, and the School of Hawaiian, Asian and Pacific Studies. Other campuses such as the University of Hawaii at Hilo have marine-related education programs including the Marine Option Program, Summer Marine Studies Program, the proposed Kalakaua Undergraduate Marine Center and a proposed marine laboratory at Puako. Windward Community College operates the Hawaii Backyard Aquaculture Program and both Windward and Maui Community Colleges operate Marine Option Programs.

Curriculum development and general support for State programs in marine education are provided by the Office of Instructional Services, Department of Education (DOE), and the University of Hawaii Curriculum Research and Development Group. Within the Office of Instructional Services, there is one resource teacher to help support marine and other aquatic education for grades K-12 statewide. Additionally, there are a total of eight environmental education specialists, one for each of the seven school districts and one with statewide responsibilities. The environmental education specialists cover marine education as well as terrestrial, space, resource management and energy education. To varying degrees, marine education also is being delivered through other subject areas such as science and social studies. The University of Hawaii Curriculum Research and Development Group has two staff specialists dedicated to marine education. The group is highly interdisciplinary in its composition and works cooperatively with numerous schools and colleges within UH and DOE.

The University of Hawaii Sea Grant Extension Service (SGES) promotes wise use of ocean resources through education and outreach. SGES operates programs of statewide scope and importance and has agents on Oahu and the Big Island (Hawaii). There also is a cadre of education specialists in State government active in marine programs e.g., Division of Aquatic Resources, Department of Land and Natural Resources (DLNR), Energy Division, Department of Business, Economic Development and Tourism (DBED) and Litter Control Office, Department of Health (DOH).

Coordination

As noted, there is a varied array of programs and facilities serving marine education and research functions in Hawaii. Many of these programs receive direct or indirect funding from the State, or the facilities are on property owned by or leased from the State. Most are operated independently of the others and to a degree compete among themselves for their clientele. The Legislature has long recognized the need for some form of coordination among these interests to promote greater awareness, understanding and appreciation of the ocean.

The 1987 Legislature established the Hawaii Ocean Center Planning Council to assist the Office of State Planning (OSP) in achieving this objective. The Hawaii Ocean Center (HOC)

Planning Council is an advisory body appointed by the Governor consisting of 15 members including representatives from the University of Hawaii; the State Departments of Land and Natural Resources, Business, Economic Development and Tourism, Education, Transportation, Accounting and General Services, and Health; the City Department of General Planning; the Hawaii Visitors Bureau; the Waikiki Aquarium; and members of the public with a strong interest in Hawaii's ocean and its resources. The HOC Planning Council has recommended that its composition be amended to include representatives of each of the Neighbor Island Counties and the Hawaiian community (OSP 1990).

The HOC Planning Council also has recommended that a Hawaii Ocean Center be established as a network of satellite centers and ocean-related programs throughout the State. Existing facilities and programs, as well as new ones, should have an opportunity to join the network. The HOC Network could facilitate coordination without the need for authority over management and operation of member centers and programs. Work on further developing and operationalizing this concept is continuing.

General Infrastructure Support

The Department of Transportation (DOT) Harbors Division is involved in infrastructure development through harbor expansion, management and maintenance in support of research vessels homeported here as well as research vessels transiting Hawaii from other locations. In 1989, Harbors Division had responsibility for ten major commercial harbors, 18 small boat harbors and 50 boat ramps (see Harbors Technical Paper). These facilities, together with Snug Harbor from which most of the University of Hawaii's and the National Marine Fisheries Service's research vessels operate, form an intricate network of surface support enabling statewide and Pacific-wide operational capabilities.

Complementing Hawaii's modern ports are highly developed aviation and telecommunication links. More than 30 major air carriers fly more than 100 scheduled, daily passenger and cargo routes to national and international destinations. Scores of flights connect the State's major islands. DOT's Airports Division is responsible for airport operation, maintenance and expansion. Hawaii's telecommunications capabilities are state-of-the-art, offering a recently completed 40,000-circuit fiber-optic cable linking Hawaii with the U.S. Mainland, Japan, Korea and Australia. Additional telecommunications infrastructure expansion and upgrades are being sought by the High Technology Development Corporation attached administratively to DBED. Ocean research and education are labor intensive and information driven. A high capacity for rapid exchange of people and data is crucial to competitive performance and productivity.

Industry Marketing and Promotion

The Ocean Resources Branch (ORB) of DBED is the lead State agency responsible for ocean R&D marketing and promotion (Chapter 201-13, HRS). ORB has completed market analyses, developed a marketing strategy and is conducting a major campaign for promoting Hawaii's ocean R&D industry. Hawaii is the only State to operate such a program. An industry advisory group is an important component of the program.

Other agencies in DBED provide additional support for ocean R&D industry development. The Business Development and Marketing Division supplements Federal Phase I SBIR (Small Business Innovative Research) grants with funds of $25,000 per grant and runs the Hawaii Trade Program, which identifies and announces worldwide funding opportunities in ocean R&D and aquaculture for Hawaii businesses and researchers. The Business Services Division operates a Capital Loan Program with a revolving fund of about $2.5 million. The High Technology Development Corporation (HTDC) sponsors numerous incubation facilities and innovation centers to encourage promising marine-related research and commercial activities. Such centers include, for example, the Kaimuki Technology Enterprise Center and the Manoa Innovation Center. The Natural Energy Laboratory of Hawaii Authority operates the Natural Energy Laboratory of Hawaii, which supports ocean research leading to commercialization, and the Hawaii Ocean Science and Technology (HOST) Park, Hawaii's first ocean science industrial park.

The Pacific Basin Development Council (PBDC), an economic development organization made up of the Governors of American Samoa, Commonwealth of the Northern Marianas, Guam and Hawaii, is looking at ways to support and encourage ocean R&D in these areas and to forge cooperative working relationships between Hawaii and these American Flag Pacific Islands.

MANAGEMENT ISSUES

Management issues associated with the ocean research and education sector in Hawaii fall into eight major categories: 1) prioritization and funding allocation, 2) market diversification, 3) user conflicts, 4) definition of "marine education," 5) attitudinal behavior, 6) care and handling of marine animals and habitats, 7) water safety and liability, and 8) ocean and coastal interpretive education. Additional issues related to research and education are presented in virtually all of the other technical papers where they can best be incorporated into resource- or activity-specific management strategies.

Prioritization and Funding Allocation

In this age of increasing economic competitiveness, State spending patterns for ocean R&D need to be viewed as strategic components of State policy. State matching funds could be used to attract large Federal research contracts. This form of leveraging results in high economic impact. State investment in this manner has a history of generating short-term returns of two to four Federal dollars for every State dollar spent for ocean R&D (DOE 1988) and in the long-term has increased business oppor-

tunities in the private sector (e.g., Fast and Tanoue 1988). Substantial capital inputs also could result from using State funds in this way to attract Federal Centers of Excellence which would contribute greatly to Hawaii building a more nationally competitive infrastructure for ocean R&D.

Hawaii relies on the Federal government for 83 percent of its ocean R&D revenues. The environment in which Federal funding decisions are made is highly political; competition between states for Federal support is especially keen. Federal spending for ocean R&D is projected to remain essentially level in real terms through 1996 if not over the entire decade (MacDonald et al 1990). Hawaii will have to be strongly competitive with other states to increase its proportional share of these funds.

To be most effective economically, there needs to be a formal framework to guide State ocean research prioritization and funding allocation. State appropriations to match and attract federally funded research dollars need to be purposefully based on a program's economic impact as well as on its intrinsic merit. Some balance between economic leveraging power and program appropriateness would have to be devised, as would a mechanism to centralize decision making and advise the Legislature. There also would have to be a plurality of interests represented in the process to accommodate all of the major categories of performers (e.g. government agencies, businesses, nonprofit organizations and the University of Hawaii) involved in ocean R&D in Hawaii.

The State Marine Affairs Coordinator originally served this function for ocean R&D. The 1982 Legislature abolished the position and Office of the Marine Affairs Coordinator and transferred the powers and duties of that Office to DBED (Legislative Reference Bureau 1982).

Market Diversification

As noted, Hawaii's ocean R&D industry is heavily dependent upon Federal spending. The general outlook is favorable, but the U.S. budget and trade deficits and the pending "peace dividend" are major uncertainties facing this industry. Hawaii needs to distribute its risk by establishing new markets in other countries around the Pacific Rim.

Foreign spending for ocean R&D in Hawaii increased by 46 percent between 1987 and 1989, totalling $6.5 million (MacDonald and LaBarge 1990). Annual foreign spending during this period was 2.5 times greater than in any prior recorded year (1980-1986). This amount is not great compared to Federal sources. However, foreign spending has the potential to become the largest nonfederal source of ocean R&D funds for Hawaii.

Foreign spending during this period chiefly involved two countries: Japan (61 percent) and Singapore (15 percent). Fourteen other countries contributed in lesser amounts but demonstrated client interest and market possibilities around the Pacific Rim (e.g. Canada, El Salvador, Ecuador, Venezuela, Australia, Taiwan, Korea and a variety of Pacific Island nations). Opportunities afforded by these and other candidate countries need to be identified and aggressively pursued.

User Conflicts

User conflicts within and between ocean recreation and fishing activities are now legend in Hawaii. There is a growing incidence of conflicts involving these activities and research and education activities in the nearshore environments of the populated main islands. Ocean research and education need to be recognized as legitimate ocean uses on par with and deserving the same considerations afforded any other ocean use activity in Hawaii.

Research-Related

The problem is particularly acute where disturbance of carefully controlled experiments and interruption of long-term studies diminishes or jeopardizes the integrity and completeness of the research results. That possibility is especially likely in the case of artificial reef-related work and where extensive floating or submerged instrumentation and sampling arrays are involved. The result could be an undetected bias leading to faulty conclusions or premature termination of the project if interference were overt. Both results damage Hawaii's reputation as a major center for credible research resulting in reduced possibility of continued funding and serious damage to the professional reputations of the researchers involved. A related threat derives from the potential impacts of coastal development on critical or unique research areas that may inadvertently be degraded or destroyed.

Expansion of the ocean R&D industry and strengthened marine research curricula in Hawaii's universities and Department of Education ultimately will lead to increased use of the ocean for research and education and to heightened conflicts with other ocean users, unless appropriate management measures are devised and taken. Most recently, the 1988 Legislature requested that an artificial reef zone be established for research and other nonconsumptive uses (H.C.R. No. 207, H.D.1), but no law was enacted. The only legal mechanism currently enabling exclusive use of the ocean for research and education purposes is Chapter 190D, Hawaii Revised Statutes. This law provides for leasing the ocean within State waters but is narrowly framed and so restrictive that it is of limited applicability.

Education-Related

User conflicts also occur during field trips for educational purposes, most notably at such popular tide pool locations as Maile Reef, Makapuu and Portlock. These conflicts generally involve shoreline fishermen or occur between the different field trip groups themselves. Field trips are conducted by virtually all grade levels in public and private schools, by nonprofit groups such as Sea Life Park and the Waikiki Aquarium and by a variety of undergraduate and graduate programs in all of Hawaii's colleges and universities.

Conflicts involving multiple field trips at a single tide pool or reef flat site are perhaps the most troublesome kind. The educational opportunity being offered is diminished. The re-

sulting congestion contributes to overuse of the site and to resource degradation, which further reduces the educational value of the experience. This problem is greatly aggravated by two factors: 1) the convergence of users at preferred locations at the same time because of favorable conditions caused by the tides, and 2) the small number of appropriate sites that can serve as alternatives to disperse and distribute the effort.

The matter of access is also an issue in this case because of the limited extent of protected shoreline suitable for field trip use, especially by elementary school grades. Access is restricted primarily by home owners at such preferred study locations as Kawela Bay and the Portlock area and by the military at certain bases where the physical conditions for reef and tide pool study are exceptional. Little can be done to control the timing of the tides, but conflicts could be reduced among the educational groups involved by more tightly organizing the user schedules and by seeking additional access to new sites from the proper military authorities. The matter of access being restricted by home owners is addressed more thoroughly elsewhere for beaches and coastal erosion (see Beaches and Coastal Erosion Technical Paper) and ocean recreation (see Ocean Recreation Technical Paper).

Definition of "Marine Education"

There is growing interest among the general public for interpretation and display at popular resource sites (e.g. Hanauma Bay) and growing demand for general information on marine-related matters. In response, an array of governmental, nonprofit and volunteer organizations as well as businesses are offering a wide range of information services and products. This is a desirable trend which ultimately will lead to a more sophisticated body politic and marine constituency in Hawaii and should be encouraged. However, management problems are arising in regard to the interpretation of what constitutes "marine education." The concept of quality control needs to be introduced in relation to the educational programs offered.

For example, the Department of Parks and Recreation, City and County of Honolulu, has adopted administrative rules intended to reduce use of Hanauma Bay Beach Park to a level that is less damaging to the bay's environment. The regulations adopted also are intended to reduce the commercial use of public facilities and increase the educational value of the resource. But, some tour operators provide "educational" activities as a part of their package and seek continued commercial access on that basis. For this reason, the City and County of Honolulu has had to rethink its administrative rules.

The number of accessible major and unique ocean and coastal resource sites statewide are relatively few. Almost certainly public use of them will exceed their environmental capacities, as occurred at Hanauma Bay, if limits are not set on the kinds and levels of activities that are to be permitted. As part of the process that establishes such limits, marine education will have to be clearly defined to prevent unintended uses. This precaution is especially important in the face of growing demand for "ecotourism" and the rise in the number of businesses and organizations that are catering to this market segment. As noted above, this is a desirable trend but there are associated impacts that cannot be ignored and which will have to be carefully managed.

Attitudinal Behavior

The reduction in educational value visited upon popular tide pool and other coastal field trip sites derives as much from "misuse" as from "overuse." The behavior of educators intent on providing specimens for demonstration purposes may fall short of what is required to maintain the sustained viability of the marine community they so routinely sample. For example, care must be provided and survivorship should be highly considered in holding and returning live specimens to the tide pool or reef environment after the class or field trip is over.

The teaching should be to understand and appreciate the ocean system. Students of all ages should first be taught to care in order that they may validate the diversity of Hawaii's marine life. Informed attitude is the key to developing a conservation ethic and practicing responsible ocean and coastal stewardship. Educators and all environmental interpreters are role models for students and the general public and they need to manifest this caring attitude in their behavior.

Care and Handling of Marine Animals and Habitats

Nationally, there is mounting interest in assuring that marine animals held captive for educational and research purposes be properly and considerately cared for and maintained. This has been especially true for marine mammals, but it is expected to apply more forcefully in the future to fish and invertebrates as well. A number of professional societies are establishing standards and guidelines for their memberships to follow. These organizations include, for example, the American Association of Zoological Parks and Aquariums, American Society of Zoologists, Animal Behavior Society, Ecological Society of America and International Union for the Conservation of Nature and Natural Resources.

In any set of guidelines it would be necessary to differentiate between care and handling: 1) while in the field, 2) while in transport, 3) while in the controlled, monitored classroom environment (temporary), 4) while in zoos, aquariums, oceanariums or related facilities (permanent), and 5) in the use of prepared specimens. These guidelines should be extended to include the treatment of marine and coastal habitats. It also would be desirable that commercial operators engaged in "ecotourism" be involved in this process and abide by the guidelines as well.

The Department of Education has on hand a set of general guidelines urging that thoughtful consideration be given by teachers and students when using the various marine environments for educational purposes (DOE 1983). The Waikiki Aquarium has adopted specific animal handling instructions for their docents and interpreters as have several other such marine resource centers in Hawaii. However, with the growing power

and popularity of national animal rights groups like the 300,000-member People for the Ethical Treatment of Animals, the State needs to consider a more formal position statement supporting responsible research and education, as much to protect research and education and their contribution to the State as to protect the organisms and their habitats.

Water Safety and Liability

Water safety and liability are contentious issues of notable importance. The personal welfare of students must be provided for in balancing potential risks against the benefits of hands-on experience and field observation. Course work and visual aids are fine, but true literacy in marine-related fields requires direct exposure to foster full understanding and appreciation.

Regulations regarding planning, authorization and safety provisions for water-related field trips in natural environments are stipulated in Section 2250.1, DOE Policies and Regulations. It is recommended by the districts that approval of a water-related field trip request submitted by a teacher be made by the district superintendent rather than the school principal, as otherwise would be the case. Risk and liability are deemed higher for such field trips and requires a higher level of authorization than usual. The general safety guidelines and provisions for water-related field trips adhered to by DOE are included in the publication *A Compendium: Coastal Field Sites in the State of Hawaii* (ibid).

In order to make wise decisions, there is a need for administrators to personally experience the same kind of field trip conditions as their students. The administrator's informed familiarity with marine educational programs, including actual field site visitation, seems crucial if the administrators are to thoroughly and properly assess matters of student safety and liability.

The matter of water safety on field trips relates broadly to other DOE policies. Ultimately at issue is whether or not Hawaii's children have been instructed in water safety and can swim. DOE does provide formal water safety and swimming instruction for its students. Yet, many students are not making full use of this program because of a need for more facilities, staffing and funding. The lack of water safety and education programs in Hawaii is also an issue for the ocean recreation sector (see Ocean Recreation Technical Paper).

Ocean and Coastal Interpretive Education

As part of the overall effort to raise the level of marine literacy in Hawaii and to generate responsible stewardship, there is a need for greater public awareness of Hawaii's scenic, natural and cultural/historic ocean and coastal resources. Ocean and coastal interpretive education can help residents and tourists (including in-state travelers) better appreciate and understand what these resources have to offer in regards to their beauty, qualities and special meaning (DBED 1988). This appreciation in turn instills a heightened sense of value which leads to increased care and concern that these resources be wisely managed.

There are no statewide or regional ocean and coastal interpretive plans in Hawaii, only some for specific sites. A few of Hawaii's coastal attractions have interpretive signs (e.g., Kahaluu Beach Park, Richardson Ocean Center, Wahaula Visitor Center). Most only identify the name of the site, with little or no additional information provided. Often, the signs are too brief and printed only in English. A relatively cost-effective means of educating very large numbers of people, including school students, about Hawaii's ocean resources is being underutilized.

RECOMMENDATIONS

Objective

Develop a supportive State management system that encourages and promotes marine education and that fosters the growth, continued economic viability and effectiveness of ocean research and development in Hawaii.

Policy A

Strengthen Hawaii's national and international competitiveness in attracting funds for ocean research and education.

Implementing Actions:

DBED should:

1. Continue to implement its marketing and promotional strategy to increase Federal spending for ocean research and development (R&D) in Hawaii.

2. Conduct a market analysis and develop and implement a marketing and promotional strategy to diversify and expand Hawaii's ocean R&D opportunities in Pacific Basin countries.

3. Extend the funding source listings in the Hawaii Trade Program to include regional consulting opportunities in marine education as well as ocean R&D.

Policy B

Mitigate user conflicts between research and non-compatible ocean use activities so that ocean research projects are not jeopardized.

Implementing Actions:

DLNR should:

1. Amend the ocean leasing law (Chapter 190D, HRS) to make it a more effective mechanism in support of ocean R&D.

2. Establish an artificial reef zone for research and other nonconsumptive uses at an appropriate site on a "pilot" basis. After a reasonable time period, assess the utilization and effectiveness of the zone to decide on the continuance of this site designation and possible extension of the zoning concept to other areas and research uses.

Policy C

Reduce user conflicts among marine-related groups and prevent overuse of the most preferred coastal field trip sites.

Implementing Actions:

DLNR, in consultation with DOE and affected marine resource centers and programs, should:

1. Designate and manage the most suitable coastal field trip sites as Marine Life Conservation Districts or as other kinds of management areas to enhance and provide for their greatest educational value.

DOE should:

2. Make greater programmatic use of Hawaii's marine resource centers as substitutes for field trip visitation whenever appropriate.

When established, the HOC should:

3. Coordinate regular scheduling for coastal field trips to reduce congestion and disperse use.

4. Seek additional access to new field trip sites from the proper military authorities.

Policy D

Ensure that proper stewardship attitudes are manifested among educators and other interpreters and students.

Implementing Actions:

UH and DOE together should:

1. Collaborate, draft and adopt a formal position statement that sets guidelines for the conduct of responsible research and education activities including that marine animals and their habitats are properly cared for and respected.

2. Directly involve and coordinate this effort with Hawaii's marine resource centers, schools and other appropriate government agencies and user groups.

3. Provide teacher training to develop marine literacy and to foster positive stewardship for the marine environment.

4. Coordinate partnerships with governmental, community and business agencies to provide supplemental instruction in stewardship.

DOE should:

5. Provide teacher resource positions in each school district to assist with teacher training and direct services to students (in class and in the field environment). [Currently, there is one resource teacher to help support marine and other aquatic education for grades K-12 statewide.]

Policy E

Prevent unintended activities from occurring in Hawaii's marine and coastal protected areas.

Implementing Actions:

DLNR should:

1. Clearly define "marine education" in whatever formal process is adopted to manage the resources under its jurisdiction so that the intent and meaning of the term is precise and unequivocal. [See Policy C, Action 1.]

2. Coordinate the formulation of this definition with the Counties and Federal government where overlapping jurisdictions and shared boundaries occur.

3. When formulating this definition, give credence to the ocean recreation/tour industry as an educational source which can supplement government resources.

Policy F

Ensure that Hawaii's school students are safe around the water and derive maximum benefit from ocean-related field trips and excursions.

Implementing Actions:

DOE should:

1. Require students to participate in a water safety/learn-to-swim program. Seek mandatory funding to support this program.

2. Require administrators and teachers to participate in water safety workshops.

3. Complement coastal-site visits with carefully coordinated excursions to marine resource centers. [This has the added benefit of not contributing to overuse of field-trip sites (see Policy C, Action 2).] Additional staffing is needed to provide specialized instructions to students.

4. Coordinate/collaborate field trip objectives at the school level to avoid duplication in learning experiences.

5. Secure new funding for "in-the-environment" experiences which are more costly to provide than shore-based excursions.

Policy G

Increase public awareness of Hawaii's scenic natural and cultural/historic ocean and coastal resources through interpretive education.

Implementing Actions:

DLNR should:

1. Develop and implement statewide and regional ocean and coastal interpretive plans, including recommended sites, resource information, facilities, staffing, funding and programmatic needs.

2. Develop multilingual signs (especially Japanese) to help visitors and Hawaii's multi-ethnic population to better appreciate sites.

3. Work collaboratively and coordinate interpretive programs with the Counties and Federal government to encourage opportunities for joint agreements and shared resources and expertise.

NOTES

1. This section is drawn largely from "A rising tide of investment opportunities: Hawaii's ocean industries." State of Hawaii Department of Business and Economic Development. 1989. p.5.

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OCEAN RECREATION

THE RESOURCE

Hawaii's ocean and shoreline areas offer residents and visitors year-round opportunities to engage in a diverse array of recreational and commercial activities. Coastal areas offer both a range of passive activities from sunbathing and walking to shoreline fishing, and more acitive pursuits, such as swimming, scuba diving, surfing, paddling, windsurfing, boating and water skiing. In addition to these independent recreational opportunities, a wide array of commercial activities is available, including dive tours, boat tours, interisland cruise ships, parasailing and jetskiing. One of the newest is commercial submarine tours.

For Hawaii's residents, going to the shoreline is a favorite leisure activity. Passive enjoyment of coastal areas is popular with residents and tourists alike. Based on 1985 State Comprehensive Outdoor Recreation Plan (SCORP) statistics, at least 170,000 people swim or sunbathe at beaches or shorelines, on a typically busy day. Seaward of the shoreline, other forms of ocean recreation are being enjoyed. Some 23,000 people are surfing. Almost 25,000 others are fishing either ashore or afloat. Some 3,000 people are paddling canoes or kayaks, while more than 18,000 are enjoying other kinds of boating. Beneath the surface, some 21,000 people are diving.

Hawaii has always promoted its tourism industry on the basis of the Islands' natural beauty. This is especially true of Hawaii's coastal areas, beaches, shorelines and nearshore waters, which are considered vital to the State's ocean recreation and tourism industries (DBED 1988). Hawaii has developed its diverse opportunities for ocean recreation into a major industry with annual revenues that are projected to approach $500 million in 1990 (MacDonald and Deese 1989). An important factor in this success is the increase in the number of tourists, who cite ocean recreation activities as one of the main reasons they come to Hawaii. The Hawaii Visitors Bureau estimates that total visitor expenditures in 1988 were $9.2 billion (DBED 1989). Sporting events such as surfing, bodyboarding and windsurfing contests, major yacht races, competitive ocean swims and endurance events, fishing tournaments and canoe and kayak races are also a major source of ocean recreation revenues.

The 1990 SCORP provides updated information on Hawaii visitor and resident recreation patterns. According to SCORP statistics, 85 percent of visitors to Hawaii participate in some form of ocean recreation. Residents also listed going to the shoreline as one of their favorite leisure activities.

It is expected that ocean recreation activities will become increasingly important, both socially and economically, to Hawaii. Innovations in designs and materials will provide additional opportunities for expanding the ocean recreation industry. The overall growth of the ocean recreation industry between 1981 and 1986 was dramatic, averaging revenue increases of 16 percent per year compared to 11 percent per year for tourism. Growth from 1986 to 1990 was projected to bring a 74 percent increase in revenues and a 47 percent increase in employment. If realized, the ocean recreation industry would reap the greatest economic gains among all of Hawaii's ocean industries (ibid).

RESOURCE MANAGEMENT

Regulation and Enforcement

There are many Federal, State and County laws and regulations pertaining to the use of recreational resources. The enforcement of these rules and regulations is carried out by the U S Coast Guard, Department of Land and Natural Resources (DLNR), Department of Transportation (DOT), Department of Health (DOH), and County parks and police departments. The rules not only define the enforcement responsibilities for each agency but also delineate the boundaries of each agency's jurisdiction.

On the Water

Most water-related activities are jointly managed by the Federal government and the State of Hawaii.

Federal Authority. The Federal government and the State have joint management responsibilities for water-related activities. The State DOT and the Coast Guard exercise concurrent authority over those waters within the State's jurisdiction. Outside the limit of the State's jurisdiction the Coast Guard has authority to the limit of the Exclusive Economic Zone. Hawaii's DOT has exclusive jurisdiction over inland waters and those waters not under Federal jurisdiction. DOT and the Coast Guard coordinate law enforcement patrols on all waters subject to concurrent jurisdiction. This coordination avoids duplication of efforts and provides the most effective law enforcement possible with the vessels and personnel available.

DOT has primary law enforcement responsibility for recreational vessels within the waters under the joint jurisdiction of the State and Federal governments. The Coast Guard has exclusive responsibility for the enforcement of vessel inspection and related Federal statutes applicable to non-recreational vessels. Whenever possible, DOT and the Coast Guard cooperate in developing public boating safety education programs. DOT and the Coast Guard also coordinate search and rescue operations; however, due to a lack of manpower and equipment, this function lies mainly with the Coast Guard. Under the National Recreational Boating Safety Program (46 USC 13102), the State is eligible for Federal financial assistance for vessel registration and a marine casualties reporting system, cooperative boating safety assistance, patrol and enforcement, boating safety education, aids to navigation, and public facilities built after 1986 (U.S. Coast Guard 1987).

The U.S. Army Corps of Engineers (COE) and DOT also develop and maintain all State harbor facilities. There are also a few privately owned and operated facilities as well as military marinas (see Harbors Technical Paper).

Offshore mooring activities are under joint jurisdiction. Commercial offshore mooring permit applications are coordinated by COE. A thorough review by all agencies charged with managing marine resources is required, often through the development of an Environmental Assessment or an Environmental Impact Statement. Since DOT has jurisdiction over State waters, it must review applications for the impact a mooring buoy will have on other water-related uses. The Board of Land and Natural Resources is statutorily mandated to manage all conservation lands. The Board is chaired and staffed by DLNR, which has jurisdiction over all conservation lands including submerged lands within the State's waters. DLNR requires all mooring applicants to submit a Conservation District Use Application (CDUA) and obtain approval from the Board. A disposition by the Land Manangement Division also is needed. DLNR reviews both its CDUA and COE permit for impacts on marine resources on submerged lands. DLNR's Aquatic Resources Division also has statutory authority to regulate the use of moorings in Marine Life Conservation Districts. The National Marine Fisheries Service (NMFS) reviews mooring applications for effects on marine protected species.

All water-related activities that occur in areas frequented by protected marine species (sea turtles and whales) are subject to restrictions established by NMFS. NMFS enforces the regulations with the assistance of DLNR's Division of Conservation and Resource Enforcement (DOCARE) and to a lesser extent, DOT's marine patrol officers (see Marine Ecosystem Protection Technical Paper).

State Authority. Within the State, DOT's Boating Branch issues rules for the "...operation, use and equipment of vessels on or in the waters of the State..."(Title 15, Chapter 266, HRS). The rules are designed to promote the full use and enjoyment of the waters of the State while ensuring the safety of persons and the protection of property. The Boating Branch also regulates all water-related activities including swimming, surfing, sailing and boating. All water-related activities are enforced by Harbors Division's marine and harbor patrol officers (Title 15, Chapter 266 and 267, HRS; Chapter 19-86, HAR). DOT's Boating Branch also issues permits for all commercial ocean recreation activities originating at State harbors and boat launching ramps. In addition DOT's Ocean Recreation Management Rules restrict certain commercial and non-commercial uses to specific sites, and require permits for all commercial

ocean recreation activities within established Ocean Recreation Areas. Due to concerns expressed by residents, the 1990 Legislature adopted Act 313, which limits the operation of commercial thrillcraft, parasailing, water sledding, or high-speed boating to certain areas during certain days and times of year.

Recreational fishing activities are regulated by DLNR's Division of Aquatic Resources (DAR). Regulations pertaining to catch limits, gear restrictions, etc., are established by DAR and enforced by DOCARE (see Fisheries Technical Paper). DAR receives funds from the Federal government for sport fishing under the Federal Aid in Sport Fish Restoration Act (16 USC 777). These funds are currently utilized for a number of activities including aquatic education programs. At least 10 percent of the funds are required to be used to provide or improve recreational boating access (Federal Register 1990) and are transferred to DOT for this purpose.

The Department of Health (DOH) monitors water quality in all coastal waters. The frequency of monitoring is determined in part by the level of recreational use in a given area. Areas with high recreational use are monitored once per week to ensure that health and safety water quality standards are being met (see Waste Management Technical Paper).

DOH also runs a Honolulu Aquatic Safety Intervention Project at Hanauma Bay with a Federal grant from the Center for Disease Control. The project will provide findings about the impact and effectiveness of testing aquatic safety interventions such as signs and educational handouts. There is potential to apply these findings and successful intervention methods to heavily used beaches statewide; although project funding expires in 1991.

On Land

Access to ocean recreational activities is provided through harbors and boat launch ramps. Additional access is provided through Federal, State and County parks, private property (resorts), public rights-of-way, and along stretches of open shoreline.

Federal Authority: The Federal government's National Parks Service is responsible for providing access through coastal national parks. It also has authority to manage adjacent coastal waters through the Hawaii National Parks Act. Hawaii also has one National Estuarine Research Reserve (NERR) at Waimanu, Hawaii, which is administered through the National Oceanic and Atmospheric Administration (NOAA) under the Department of Commerce. The funding to administer the NERR is allocated through the National Coastal Zone Act (see Marine Ecosystem Protection Technical Paper).

State Authority: DLNR's State Parks Division regulates all State parks, recreation areas and activities under Title 12, Chapter 184, HRS. Although the Division generally doesn't issue permits for commercial ocean recreation activities, three temporary permits to commercial boat operators for landing at Na Pali Coast, Kauai, and one permit for a commercial beach concession to rent recreational equipment at Hapuna Beach Park, Hawaii, have been issued. DLNR's Land Management Division also issues beach concession leases for Duke Kahanamoku Beach in Waikiki. State Parks also manages and maintains two recreational fishing piers on Kauai.

The Federal Land and Water Conservation Fund Act (LWCF) was enacted in 1965 by the Federal government to assist states in acquisition and/or development of outdoor recreation resources. As part of the requirement to participate in the LWCF, states are required to prepare State Comprehensive Outdoor Recreation Plans (SCORP). SCORP provides an inventory of all existing Federal, State, County and private recreational facilities statewide. Under the Hawaii State Planning Act (Act 236), DLNR is charged with preparing and implementing Hawaii's Recreation Functional Plan as part of the State's Functional Planning process. The State Recreation Functional Plan and SCORP address the recreational needs of Hawaii and provide recommended actions to increase opportunities for recreation. Both SCORP and the Recreational Functional Plan are being updated. The State Recreation Functional Plan technical document also qualifies as SCORP.

All lands seaward of the shoreline to the limit of the State's jurisdiction are managed by DLNR's Division of Land Management and Office of Conservation and Environmental Affairs. Ocean recreation businesses wishing to operate in this area must submit a Conservation District Use Application (CDUA) to DLNR's Office of Conservation and Environmental Affairs and obtain a lease permit from the Land Management Division once the CDUA has been granted. Commercial operators are issued permits for their activities on a case-by-case basis. These permits are subject to interpretation by the Board of Land and Natural Resources, which considers whether the commercial operator is "staging" its activities in the conservation district or is "transiting" through conservation lands. A CDUA permit may be granted if it is determined that the proposed activity will have limited environmental impact and a negative environmental declaration is issued.

County Authority: The Counties have by far the largest role in providing access, facilities and services to non-boating ocean recreational users. Restroom and parking facilities are provided at most County and State parks. Hawaii has seven national parks, 66 State parks and 569 County parks (DBED 1989). In addition, the Counties maintain a few boat launch ramps. The Counties also provide lifeguard services at several County and a selected few State parks. Legislation enacted in 1990 will allow the Counties to provide lifeguard services at several State beaches. The Counties also provide permits for commercial ocean recreation activities at specific beach park areas. Permits are issued subject to County ordinances or through the Special Management Area (SMA) permit process mandated under the Coastal Zone Management (CZM) Law (Title 13, Chapter 205A, HRS). The Counties must coordinate the issuing of permits with DLNR for County parks that are in conservation districts.

The majority of access to the State's waters is managed under the jurisdiction of the Counties' parks and planning departments. In addition to beach parks, the Counties also are

tasked with providing and maintaining public rights-of-way to the shoreline. Developers wishing to build along the shoreline must apply for an SMA permit prior to construction and are required under CZM Law to provide public access. However, the type of access that is required varies from County to County and is subject to interpretation.

In 1988, the Hawaii State Legislature enacted the Hawaii Statewide Trail and Access System Act (Act 236). This Act, which is referred to as Na Ala Hele, assigned DLNR's Division of Forestry and Wildlife to work with the Counties to inventory existing trails and shoreline access and propose recommendations for additional needed access routes and trails. Several years ago, the Counties developed shoreline access plans, which may be updated in response to this law.

MANAGEMENT ISSUES

Lack of Resources for Recreational Opportunities

Parks and Recreation Areas

The 1990 Draft Recreational Functional Plan states that the capacity of beach parks and shoreline areas is rapidly diminishing, especially on Oahu, due to the significant number of resident and visitor users. The saturation of beach park capacity is considered a top priority issue in the Recreation Functional Plan. Additional public parks have to be planned and developed to meet the growing demand.

Camping along the shoreline is affected by several factors. Traditional undeveloped sites are being lost, or access is being limited, because of development. Shoreline camping by the homeless is impacting both designated and non-designated sites. Traditional shoreline camping grounds outside of park areas lack basic facilities, such as restroom and litter disposal services. Additional camping sities, especially in traditional camping areas, are needed.

Support Facilities

Basic Support Facilities: Many recreation activities, including windsurfing, kayaking, surfing and swimming benefit from park support facilities. Basic facilities include parking areas, restrooms and showers. Generally, the need for shoreline park areas and basic support facilities will continue to increase with population growth. The high volume of use at many recreational areas is taxing the capacity of the related support facilities. In addition, the State and Counties have expressed concerns about their ability to maintain current facilities as funding generally has been directed towards acquisition and development of new facilities. Funding for maintenance has not kept pace with the high levels of use, and in some areas has caused deterioration of facilities (DLNR 1990).

The State and the Counties maintain a number of beach parks and many shoreline resorts have developed public paths to the shoreline, which include comfort stations and parking areas. However, it is uncertain whether these facilities adequately fulfill the needs of the general public (DLNR 1990). The design of these facilities may limit the actual number of possible users, such as lack of access for the handicapped. The number of parking spaces, the distance from the parking area to the ocean, and special conditions, such as night-use prohibitions, are also examples of factors that may limit use.

Specialized Support Facilities: Inadequate facilities and programs constrain recreational opportunities. For example, there is general consensus that the availability of berths and designated mooring areas for small boats is inadequate. There are approximately 2,600 recreational boats on a waiting list for slips at small boat harbors throughout the State (DOT 1990). Support facilities, such as boat launching ramps, ice houses, fuel sources, on-land dry storage sites and dry docks also are insufficient (DLNR 1990). In addition, only a few sewage pump-out facilities are available at small boat harbors, although a sewage improvement plan for small boat harbors slowly is being implemented (see Waste Management Technical Paper). Some of the older launch sites are inadequate and do not effectively protect boats from strong ocean surges. Launching from these facilities can be extremely difficult. There is also a severe lack of harbors of refuge for small boats to seek shelter in inclement weather. A number of resorts and other private parties are considering constructing private marinas. In addition, the State has been exploring options for additional small boat harbors (see Harbors Technical Paper).

It is estimated that there are over 2,000 vessels moored or anchored offshore in State waters (Parsons 1990), because of the lack of harbor facilities. Lack of shoreside facilities for access to and from these vessels is also a problem. As the boating population increases, these problems will increase. The current mooring permit system is complex and lengthy, resulting in the installation of a significant number of illegal moorings. Boats currently moor in a haphazard manner wherever a somewhat safe anchorage is available. DOT is in the process of obtaining management authority from COE and DLNR to establish offshore mooring regulations, to include designated offshore mooring areas and day-use mooring sites. However, discussions to develop these regulations have continued for at least three years without any significant strides toward establishment of offshore mooring areas.

The diving industry and others have been lobbying for installation of day-use moorings to eliminate some of the damage to coral caused by anchoring. However, moorings fall under the jurisdiction of both DOT and DLNR and must be approved by both agencies. Although day-use moorings were installed at Molokini because of coral damage and safety concerns, no additional day-use moorings were approved until recently. After three years of attempts to get a day-use program established, frustrated divers and others in West Hawaii installed day-use moorings along the entire Kona coast to save the coral and force the State to act. DLNR does not feel that the user groups acted in good faith as mooring system negotiations were ongoing: however, DLNR recently gave DOT approval to allow the temporary use of these moorings to evaluate their design as a prototype for statewide application.

There are two fishing piers on Kauai maintained by DLNR's State Parks Division. There is also a fishing pier at Hanalei, Kauai, which is under the jursidiction of DOT; however, it is in disrepair. Funds have been allocated to DLNR for its restoration and DOT plans to turn the pier over to DLNR once restoration has begun. DOT is proposing that Mala Wharf in Lahaina also be turned over to State Parks. It is also in disrepair. No new capital improvement money has beed budgeted in recent years for these DOT piers. Funds should be allocated for their repair and maintenance.

Specialized facilities, such as launching areas and storage facilities for outrigger canoes, kayaks, surfboards and windsurfers, are needed in any program supporting ocean recreation. The American Canoe Association, Hawaii Division, conservatively estimates that there are 10,000 canoers in the State. Outrigger canoeing, kayaking and other ocean sports have grown significantly in recent years (DLNR 1990). Storage facilities are needed, especially for those individuals living in apartment complexes who have no place to store their recreational equipment.

Public Access

Actual physical access to and along the shoreline is another recreational issue. Problems related to this issue include the loss of shoreline recreational areas and restriction of public access due to new development. These access issues will become critical as more lands are developed for resorts, houses and golf courses (DLNR 1990). There is no plan for access in as yet undeveloped areas.

Access to Shoreline Areas: In some areas, private property and private developments block access from the nearest developed public roadway to the shoreline or, as in some coastal resort areas, public rights-of-way are provided but there is no parking. In these cases, public access agreements with landowners or acquisition of public rights-of-way from inland areas to the shoreline may be necessary to provide access. In other areas, access is poorly marked or public rights-of-way have been absorbed by the adjacent private property owner, thus eliminating access. The 1990 Draft Recreation Functional Plan indicates that access paths have been fenced or blocked illegally, signs indicating public access have been torn down and access ways have become impassable due to uncontrolled weeds and brush. Access can be further limited by providing only a few parking stalls for general public use and not allowing any additional public entry once these few stalls are filled. Any leasing of property from DOT must have a provision for access but the type of access varies. The Counties on each Island and the State Parks Division have various plans to obtain additional lands for public access and shoreline parks, but the rate of implementation varies from County to County and has been constrained by a lack of resources.

It should be noted that providing additional public access to the ocean creates additional impacts and sometimes increases the potential for conflicts. As additional access is opened, low impact sites are confronted with increased levels of use and traditional users, e.g. swimmers and shoreline fishermen, may have to compete with other ocean users who were once unable to obtain access. Planning to mitigate or minimize additional impacts is a necessary part of any access plan.

Public access on military lands also is often restricted. In several instances, however, the military has cooperated with State and County agencies to allow controlled access to popular recreational areas through memoranda of agreement. However, the military has not taken an active role in implementing these agreements. Current access to military lands and recreational facilities is limited and expanded access is needed.

It may be desirable to maintain limited access to certain locations to preserve wilderness qualities or to prevent overuse, especially in areas with threatened or endangered species. The north shores of Molokai, Hawaii and Kauai are examples of areas that could be designated as wilderness areas where access should continue to be limited (see Marine Ecosystem Protection Technical Paper). Limiting certain types of commercial activities to certain shoreline areas is another access issue. Maintenance, liability and vandalism are also important issues with regard to public access. In many instances, private property owners are unwilling to provide public access because of the fear of litigation if someone is injured while crossing their property. Relief of the burden of liability to allow public access through government and private property without fear of being sued is needed.

Access Along the Shoreline: Physical access along the shoreline is not always continuous. In many areas around the Islands, manmade structures (including seawalls, revetments, groins, and canal or drainage outlets) and natural features (such as cliffs, vegetation and rocky outcroppings) restrict access to potential recreational resources (see Beaches and Coastal Erosion Technical Paper).

Safety and Education Programs

The safety of people engaged in ocean recreation activities is of major concern. In 1989, there were 705 water rescues on beaches guarded by City and County of Honolulu lifeguards (DBED 1989). The Department of Health has stated that drownings are the second leading cause of accidental death in Hawaii (DLNR 1990). Safety-oriented programs involve both conventional life-saving activities such as lifeguarding and preventive activities such as training in recreation activity skills and education about ocean resources, hazards and regulations. Planning for water-safety concerns among residents and visitors is fragmented and diffused across multiple agencies including the Counties, DOH, DOT, DLNR, DOE and the visitor industry.

Lifeguards are stationed at many County beach parks, but many popular beaches including most State beach parks are unattended. In an effort to resolve the issue of unguarded beaches, the 1990 Legislature passed enabling legislation which allows the State to work with the Counties to provide lifeguarding services at selected State beach parks. Before the State and the

Counties implement this legislation, there are still some serious issues to be resolved, mainly stemming from concerns about which agency is liable once the lifeguarding services are provided. In addition, the need to broaden the legislation to include all State beaches instead of just State beach parks was expressed by the State Parks Division (Nagata 1990).

In a State surrounded by water, it is estimated that many residents do not know how to swim (Sullivan 1990). Water-related accidents among residents and visitors are numerous, with more fatalities involving residents than visitors. Education and training programs can help reduce safety problems. These range from training for first-time users on the proper use of equipment, and interpretive programs about the resources, to providing information on regulations. Instruction in general water-safety principles and basic swimming skills are important components of safety intervention as are the posting of warning signs and development of informational brochures. Very few, if any, of these types of programs exist. In addition, on some Islands, there are very few shoreline areas with beaches safe for swimming, especially for families with small children. Often children swim in the calm waters surrounding boat launch ramps, even though it is illegal, because there are no other safe places to swim.

DOE has a strict policy on ocean recreation activities. There are no ocean activities allowed in school districts, except when they are approved by the district superintendent. It is left up to individual principals to decide where their priority funds are to be spent. Not many principals are willing to fund water-safety programs with priority funds as there are so many other projects for which the funds are needed. There is, therefore, no formal water-safety education in the public schools. An island-wide program did exist for a few years, but it was cancelled by the Board of Education due to liability concerns (Sullivan 1990).

There is no comprehensive program within the visitor industry to inform visitors of water-safety concerns, but some individual companies offer information to their clients. Liability is the main concern cited as the reason that no comprehensive approach to water-safety information has been developed. It is generally assumed that by taking responsibility for informing clients of water-safety concerns, a business or organization thereby assumes liability for the individual. However, in a recent court case in Kaanapali, Maui, a hotel was found liable for not adequately informing a guest about the rough surf at the hotel's beachfront. The liability issue needs to be resolved so that safety information can be prepared and presented.

Support for Ocean Recreation Industry

As previously noted, the ocean recreation industry was headed toward $500 million in annual revenues in 1990. Yet improvements to harbor facilities and supporting infrastructure for the ocean recreation industry and sporting events have not kept pace with the growth of the industry. The processes for obtaining permits for commercial ocean recreation ventures and major sporting events can be complex and lengthy. The industry has expressed frustration with not knowing where to go to obtain the proper permits for sporting events and the number of agencies that are involved in the permit process (Allara 1990). Plans for an international event, the Hawaii Pacific games, were put on hold because of the lack of major sporting facilities to provide venues for teams from 30 different countries (ibid). Major sporting events are telecast worldwide and provide excellent exposure of the types and variety of ocean recreational opportunities available in a scenic Hawaiian setting.

Commercial ocean recreation activities provide opportunities for both visitors and residents to participate in activities that would otherwise be unavailable. In addition, a number of commercial vendors provide instructional programs to both residents and visitors. Often, commercial operators provide rescue services to all ocean users in areas where the services would not otherwise be provided. It is generally felt that patrons will use the equipment regardless of whether there are qualified and trained personnel to supervise the activity and the commercial vendors provide a safety factor by being on the site to supervise the activity.

The majority of visitors to Hawaii come in part to participate in some form of ocean recreational activity. Promoting tourism while not supporting the types of activities tourists seek to participate in, indicates a conflict. Although the industry provides numerous benefits, its large size and rapid growth have increased conflicts among users. Public policy, expressed by Legislative initiative, acknowledges a lack of support for the ocean recreation industry. Act 313, SLH 1990, states that "...the State is mindful that in managing and regulating ocean use, priority should be given to those seeking non-commercial recreational opportunities as opposed to those seeking commercial recreational opportunities. To be a commercial operator is a privilege and not an exclusive right." As the tourism industry continues to grow, demand for more commercial ocean recreation opportunities also will continue to increase. Greater support for this industry is needed to provide the infrastructure necessary to reduce conflicts at areas heavily used by both commercial and non-commercial users.

User Conflicts

Incompatible Uses

Competition among recreational users for limited ocean recreational resources and the accompanying support facilities is a growing concern. The problems range from inconveniences, such as limited parking spaces, crowded beaches and reduced fish catches, to swimmers or snorkelers being injured by boats, etc. Boating in swimming areas and jetskiing in surfing areas are examples of incompatible activities that involve serious safety concerns. Traditional uses, such as recreational fishing, often compete for the same resource area as users of new equipment, such as windsurfers. There is also competition among recreational groups, such as shoreline fishermen and gill net fishermen, or recreational trollers and deep-sea charter boats, or recreational fishermen and the commercial longline

fishery (see Fisheries Technical Paper). Non-consumptive, users such as scuba dive operators, compete for the same sites as consumptive users, such as spear fishermen or aquarium fish collectors. Habitats, such as sunken ships, service the tour industry. They are also ideal habitats for fish propagation and are therefore sought as desirable fishing locations. Fishing depletes the stocks that enhance the visitors' experience.

It should be noted that although numerous conflicts have arisen, as the numbers and types of ocean recreation users increase, there also have been significant strides made to mitigate some of them in a few select locations. Two of the most noteworthy involve the agreements reached between the scuba diving industry and the tropical fish collectors off of Kona and the agreements reached between the windsurfers and other ocean recreation users along the north shore of Maui. As enforcement capabilities are lacking in a number of locations, the commercial industry also has had to assume self-policing of their activities. This works to a large extent in most locations, but as the industry grows the sheer numbers of users often in and of itself adversely impacts the resource.

The recently adopted Ocean Recreation Management Area Rules have reduced commercial vs non-commercial incompatible use conflicts and ocean-safety hazards by separating various recreational uses into designated areas, such as delineating thrillcraft zones. In addition, other management areas have been designated as swimming areas where boating is restricted. However, these rules do not cover conflicts stemming from limited facilities or overcrowding. Additional management of mixed but incompatible recreational activities is needed.

Commercial vs Non-commercial Uses

In some areas commercial activities, such as guided tours, lessons and equipment rentals, increase recreational use. Commercial use of public areas, especially parking lots, beaches and boat launching ramps, continues to generate controversy, especially when it is deemed excessive and interferes with public enjoyment. Competition between commercial windsurfing operations and individual users at Oahu's Kailua Beach Park has resulted in regulation of commercial activities. Of further concern is the competition between commercial uses and public use of ocean areas. For example, commercial activities in a public area effectively may prohibit public use because of competition for space and because of safety considerations.

The use of public beach parks for commercial activities occurs statewide and ranges from the already high intensity of use noted at places like Hanauma Bay, to tour buses and vans beginning to stop for picnic lunches and dropping off clients at a variety of other open shoreline areas. This issue involves not only State and County parks but also open shoreline areas outside of park boundaries and in proximity to residential neighborhoods. The commercial use of parks and shoreline areas is becoming pervasive and needs to be critically examined. As additional restrictions are imposed on park use and as the tour industry continues to grow, pressure to use these other open shoreline areas and small coastal parks is going to increase and the need to strike a balance between commercial and public use of recreational resources becomes increasingly difficult. As the competition for space between commercial operators and the general public increases, the larger concern of the appropriateness of commercial activities occurring in residential neighborhoods also needs to be addressed.

Commercialism can easily lead to overuse. It is part of the nature of the business. Without any bounds being placed on the growth of commercial ocean recreation businesses, especially in popular sites, existing operators expand their businesses and new operators enter the market as it can be a lucrative business and is basically a free resource. This expansion can eventually squeeze out the local populace and negatively impact the ocean resource the businesses are marketing. This leads residents to question commercial operations, as unbounded expansion can have detrimental impacts on the recreational resource. Governmental agencies need to recognize that the nature of a commercial business is to make money from the resource and that businesses will continue to expand while there is money to be made. A systematic approach, which defines and enforces limits on commercial growth, is needed. Under the present management system, agencies seek to limit the amount of commercial activity after detrimental effects already have occurred. This approach has not proved satisfactory for commercial operators, who may actually lose their livelihood, or residents who have been so adversely affected that they are against any commercial operations.

Natural Resource Sustainability

Degradation of Natural Resources

Recreational activities can generate adverse impacts on ocean resources. For example, coral reef communities can be damaged by anchoring of boats, such as has occurred at Molokini, or trampling by snorkelers. Strand vegetation, valuable in minimizing beach erosion and in maintaining native ecosystems, often is destroyed by pedestrians and all-terrain vehicles. Monitoring of resources and management of uses to prevent overuse can have multiple benefits to the resource and the activities. Although SCORP provides statistics on the numbers and types of recreational facilities available statewide, very few recreational sites have been studied to determine the actual number of users in a given location. Quantifiable data are lacking on the level of use at particular sites, types of activities occurring there, or impacts that activities have on the resource. Without accurate data, it is difficult to properly manage recreational resources. There is a need to monitor use and make adjustments to management practices based upon quantifiable data, at least in some of the more heavily used sites.

Commercial ocean recreation activities can blossom into major commercial ventures with potentially significant environmental and social impacts. However, an environmental impact analysis is not required when an individual company or an entire industry is growing. In addition, DOT's Ocean Recre-

ation Management regulations do not address the cumulative impacts that can occur as more and more people use the resource. Currently, there is no way to adequately examine cumulative impacts. There is also a lack of data or agreed upon methodology to determine social or environmental carrying capacities for heavily impacted recreational sites.

Marketing campaigns have designated some areas such as Molokini and Hanauma Bay as "must-see" destinations and in so doing have contributed to their overuse (DBED 1988). There is a lack of comparable sites for people to use as alternatives to those that are so heavily used and marketed and resource managers have not attempted to establish user carrying capacities.

Quality of Experience

Given the numerous opportunities for ocean recreation in Hawaii, it is understandable that residents and tourists come to expect a high-quality recreational experience. Unfulfilled expectations, a complex concept which involves individual perceptions of the availability and quality of recreational resources as well as individual preferences based on past experiences, can lead to dissatisfaction with recreational resources. Because individual preferences are involved, an area may be considered to be at a medium-use level by one person and overcrowded to another. Hanauma Bay is one area which is considered to be overcrowded by many residents. Residents confronted with increasing use of recreational resources can be more affected than visitors with no previous experience with Hawaii's coastal resources.

Increased numbers of tourists and activities are putting increasing pressures on coastal recreation resources. Twenty-eight permits were issued for hotel construction in 1987, nine in 1988 and three in 1989. Prior to this period, the State's average rate of construction for most of the past two decades had been just under two projects per year. Although the brunt of this hotel construction was felt mainly in Maui County and Kauai, the increase in the number of visitors to the Islands as a whole has outpaced the needed infrastructure improvements that should have accompanied such rapid growth. Over the next few years, several new construction permits for resort projects planned on the west and north shores of Oahu and on the Big Island may be issued. These hotel construction permits also represent a new wave of destination resort construction that will provide the foundation for tourism growth in the 1990s (Bank of Hawaii 1990). Most of these resorts will be opening for business in the next few years. Planning to alleviate the impacts of rapid development on local residents should have been anticipated or at the very least should be initiated now.

Ineffective Management and Coordination

Lack of Enforcement

Since 1988, several plans and surveys have been developed and public hearings have been held to address the growing concern of management of recreational resources. In almost all cases, lack of adequate enforcement has been cited as one of the primary reasons that management is often ineffective. The public generally feels that there are sufficient regulations to manage the resources; however, these regulations are not adequately enforced (Aotani and Associates 1988).

Although Ocean Recreation Management Rules were promulgated in 1988, DOT has had difficulty enforcing many of the new restrictions due to legal constraints and lack of resources. A campaign to educate the public on the new rules has not been undertaken. Installation of signs and/or buoys to demarcate restricted zones has not been done in most areas. Implementing the 1988 Ocean Recreation Management Rules and the new statutory restrictions mandated under Act 313 has meant a doubling in the types of operator permits and equipment registrations that are required. Although the number of enforcement personnel has increased, the number of administrative staff to process the permits has not. Effective implementation of the rules will require additional administrative and enforcement personnel, plus additional equipment.

Lack of Coordination, Cooperation Among Agencies

Current management of coastal and ocean resources is characterized by multiple responsibilities diffused across multiple agencies. This situation has made it difficult to coordinate and effectively implement the specific responsibilities of each agency. DOT and DLNR are empowered to enforce each other's rules but this does not regularly occur. Until enforcement officers are effectively trained in their own department's rules, no cross-training can occur. Enforcement capabilities are limited both by manpower and equipment shortages. There are 21 marine patrol officers statewide. DLNR's 80 DOCARE officers, who must enforce all DLNR's land and water-related regulations, are hampered in enforcing water-related regulations by a lack of boats.

DOT's marine and harbor patrol officers are scheduled to be transferred to the newly created Department of Public Safety in 1991 (Chapter 26-14.6, HRS). The new Department of Public Safety was established in an effort to formulate and implement all State policies and objectives for corrections, security, law enforcement and public safety. The Department will combine the functions of the former Department of Corrections with the sheriff's office, narcotics enforcement, and the marine and harbor police. Concerns have been expressed about this transfer, mainly due to the fact that the philosophy of resource enforcement is completely different from the philosophy of penal code regulatory enforcement. Since the general public is not required to know the rules before using a piece of recreational equipment, a large part of the marine patrol officer's job is educating the public about boating safety rules. It is uncertain how this role may change under the new department.

Gaps and overlaps in existing management authority consistently have frustrated users. People who request information complain of being referred back and forth between agencies. Primary access to marine resources occurs largely through County lands to State-managed resources. The State and Counties have not established mutually acceptable guide-

lines to manage these resources. The State can designate nearshore waters for specific activities without coordinating with the Counties to assess the impact on adjacent County-managed lands.

Agencies charged with issuing commercial permits must later assume a reactive role to mitigate negative impacts. As noted, permits for commercial activities are issued by the Counties, DLNR and DOT, depending on where the commercial activity originates and which agency has management authority. Under existing circumstances, State agencies can individually issue commercial permits for the same water area without checking with each other. Often, it is only when the cumulative impacts increase that agencies make an effort to coordinate.

Commercial ocean recreation businesses that originate from a private marina or from private property are not always required to obtain a commercial permit to operate. There is also a problem with Special Management Area (SMA) permits. Under Hawaii CZM Law, a change in the intensity of use is part of the definition used to define a "development". The County of Kauai has used this definition to require commercial boaters in Hanalei to obtain an Environmental Impact Statement prior to being issued an SMA permit to operate. The question of whether intensification of use constitutes "development" has not been adequately answered and is currently under litigation.

Lack of Adequate Funding

Growth in the visitor industry is straining recreational resources which need to be better managed and protected. Because funds have not been made available to expand their staff, management and enforcement branches are overwhelmed. DOT's Harbors Division Boating Fund is the only fund designated to maintain recreational resources and provide a small number of marine patrol officers. At a time when demands on the resource are growing at an alarming rate, there is insufficient funding or manpower to designate specific staff to ocean resource enforcement. The need to generate revenues to be used specifically for the management and enforcement of the ocean resources is critical.

RECOMMENDATIONS

Objective

Promote the development of safe ocean recreation opportunities which are socially and environmentally acceptable and compatible with other ocean and coastal resource uses and available to all residents.

Policy A

Maintain existing recreation facilities and provide needed additional recreation facilities especially in under-developed areas.

Implementing Actions:

DOT, DLNR, DBED and the Counties should:

1. Identify and prioritize ocean and coastal recreational facilities needing improvements through the State Comprehensive Ocean Recreation Plan (SCORP) and develop a plan to implement the necessary improvements which complements but is more detailed than the State Recreation Functional Plan.

2. Allocate additional funds needed to maintain current facilities properly.

3. Work with community groups to develop voluntary maintenance assistance programs to maintain recreational facilities.

   a. Set up a community "Adopt-a-Park" program.

   b. Clarify possible liability concerns so volunteers can actively participate in maintenance programs.

   c. Develop a maintenance hotline for users to report needed repairs.

   d. Develop a community liaison program that provides volunteer maintenance groups access to needed funds or supplies to maintain facilities.

4. Identify and prioritize additional site-specific recreational facilities needed for coastal and ocean recreation activities and develop them.

5. Utilize a long-range planning strategy to:

   a. Determine which underdeveloped or undeveloped recreation areas should be set aside now to ensure their development as recreational sites in the future as opposed to being slated for possible resort development.

   b. Develop methods to set aside these areas such as land banking or private/public land exchange.

6. Encourage alternative development and funding options to develop needed recreational facilities.

   a. Develop provisions for government incentives to induce private-sector investment in infrastructure development of marinas; shore-based, small boat storage facilities; shoreline parks and park facilities.

   b. Require resort marina developers to develop public boat launch ramps, boat storage facilities, parking, etc., or to develop other provisions of significant public benefit.

   c. Upgrade and maintain boat launch ramps then charge user fees for all users (commercial and non-commercial) using these facilities.

7. Establish a program to coordinate the acquisition and/or use of Federal lands, recreational facilities and waters for recreational resource development and support areas for coastal and ocean recreation activities.

DLNR and the Counties should:

8. Ensure coordination in implementing the recommendations developed in SCORP, the State Recreation Functional Plan and State or County parks development plans.

DOT should:

9. Immediately implement offshore mooring areas regulations and plans for establishment of offshore mooring and day-use mooring sites, as well as onshore support facilities.

a. Develop a one-step permit process at DOT to eliminate jurisdictional overlaps and a complex review of offshore mooring permits.

b. Encourage commercial participation in the development of day-use moorings.

Policy B

Maintain and expand access to and along the shoreline where needed.

Implementing Actions:

DLNR and the Counties should:

1. Coordinate implementation of the Statewide Trail and Access System recommendations with implementation of recommendations developed in SCORP, the State Recreation Functional Plan, County parks development plans and shoreline access plans.

2. Ensure continued funding of the Statewide Trail and Access System.

3. Ensure that expanded access does not adversely impact other ocean and coastal resources since expanded access generally means increased use of an area.

4. Maintain current access and public rights-of-way to the shoreline by:

a. Opening public access routes currently blocked by adjacent property owners or clogged by weeds.

b. Clearly mark all shoreline access and public rights-of-way and install garbage receptacles.

c. Publish guides (brochures, maps) to shoreline access locations.

d. Develop strict guidelines for private shoreline developers to ensure adequate access by developing a formula that mandates a required number of parking spaces and ancillary recreational facilities adjacent to access nodes.

5. Formulate a cooperative Federal, State and County strategy to expand public access through public and private lands to recreational areas, or expand the Statewide Trail and Access System to include Federal involvement.

6. Develop legislation to resolve liability concerns regarding access to the shoreline on government lands.

Policy C

Reserve certain areas as traditional wilderness or low impact areas.

Implementing Actions:

DLNR should:

Identify and designate wilderness and protected areas where access should remain limited, and determine acceptable levels and means of access to wilderness areas. Acceptable levels of means of access should include determination of the amount, if any, of commercial activity that should be allowed and the types of recreational equipment that may be utilized, e.g., motorized vs. non-motorized equipment. [See Marine Ecosystem Protection section.]

Policy D

Develop and support a comprehensive and coordinated water safety program which clarifies liability concerns and includes training and education.

Implementing Actions:

DLNR and the Counties should:

1. Encourage legislation to resolve the liability concerns of DLNR's State Parks Division and the Counties regarding County lifeguard services at State beach parks.

2. Seek to expand current enabling legislation that allows the State to contract with the Counties for lifeguard services to include not only State beach parks but all State beaches.

3. Continue to identify and prioritize beaches where lifeguard services are most needed.

4. Establish minimum lifeguard training standards and provide a central location for data on all water-related accidents.

DOH, in cooperation with DOT, DLNR and the Counties should:

5. Seek the necessary funding to expand the water safety intervention methods program in DOH to include all heavily impacted beaches statewide.

DLNR, DOT, DOE, DBED and the Counties should:

6. Develop informational and training programs for the general public to educate users on water safety and swimming skills, resource use restrictions, boating and water safety regulations, proper and safe use of equipment, cultural and traditional uses and conflict avoidance. Use existing Federal, State, County and private-sector programs to coordinate and enhance water safety training and education. [See Research and Education section.]

7. Establish a task force of Federal, State and County agencies and the visitor and ocean recreation industries to develop a comprehensive, systematic approach to implementing a successful water safety information program.

a. Review current liability concerns expressed by the visitor industry regarding provision of safety information to visitors and the assumption of liability that incurs.

b. Enact legislation or other means necessary to resolve these liability concerns.

c. Develop brochures and other media techniques, in a variety of languages, to inform visitors of water safety hazards.

d. Develop a comprehensive signage program to post needed warning signs. in hazardous beach and shoreline locations statewide.

DOT, DLNR and the Counties should:

8. Work with community groups to develop a coordinated volunteer search and rescue program to supplement USCG and County fire department rescue efforts.

DOE should:

9. Resolve current liability concerns regarding the teaching of swimming and consider the need to develop mandatory swimming lessons in schools. [See Ocean Research and Education section.]

DLNR, DBED, DOT and the Counties should:

10. Promote development of statewide volunteer surf/lifesaving clubs patterned after Australian clubs to work with lifeguards and commercial operators who provide rescue services.

Policy E

Maintain the environmental and social quality of recreational resources by limiting use.

Implementing Actions:

OSP, DLNR, DOT and the Counties should:

1. Develop a comprehensive inventory of nearshore and coastal resources and activities. Use this inventory to determine site-specific allocations based on quantifiable data. Make the inventory available for use by all resource managers statewide.

2. Develop a comprehensive use-level management process that requires all commercial ocean recreation ventures to obtain permits prior to being allowed to operate and require agencies to control the issuance of commercial permits once limits of use have been determined.

3. Determine the appropriate methodology to identify social and environmental carrying capacities for heavily used areas and potentially impacted areas that ensures monitoring of the impacts and limits use as needed.

a. Ensure that the methodology established is used by all agencies tasked with managing the recreational resource so that data are consistent.

b. Consider the "Limits to Acceptable Change Planning System" as one method of determining impacts and managing resources.

c. Organize a workshop of agency personnel to train all resource managers in the chosen methodology.

d. Assess impacts of current activities and set limits based on analysis of data and implementation of the methodology.

e. Ensure that the methodology can accurately determine current impacts and assess cumulative impacts as commercial activities grow.

f. Conduct an environmental assessment or a similar assessment on proposed new economic activities, in cooperation with the commercial enterprise.

4. Explore and develop options for limiting access to heavily impacted recreational sites, e.g., permits, entrance fees, etc. Develop several options for limiting access by commercial operators instead of just relying on a bidding process.

OSP, DBED, DLNR, DOT and the Counties should:

5. Work with the ocean recreation and visitor industries to develop a cooperative planning effort to disperse recreational use. Such an effort should:

a. Identify the needs of residents and visitors in determining dispersion patterns.

b. Identify and develop alternative sites that offer similar or comparable experiences to heavily used areas.

c. Analyze dispersion of use so that no single area is too heavily affected, unless it is designated for high use, e.g., Waikiki Beach.

d. Establish an effective marketing strategy to market alternative destinations to disperse use.

Policy F

Determine current and anticipated impacts of ocean recreation activities on residents and develop plans to assure that both land and sea activities are compatible with one another.

Implementing Actions:

OSP, DLNR and the Counties should:

1. Develop clearly defined policies for the commercial use of open shoreline and public beach parks in residential neighborhoods and beach parks or shoreline areas intensely used by residents.

OSP and DBED should:

2. Determine impacts from new hotel construction and develop plans to minimize these impacts.

3. Consider limiting the size of future hotel developments allowed outside specified resort nodes in order to alleviate additional impacts.

Policy G

Develop methodology to mitigate conflicts between various ocean recreational activities where the parties to the conflict can be identified.

Implementing Actions:

DOT should:

1. Hire or contract the services of mediation professionals to provide a process for conflict resolution or work with the Judiciary's Center for Alternative Dispute Resolution.

2. Develop a public information campaign on "rules of the road" and traditional uses for water-related activities to promote proper use of equipment and understanding of rights-of-way.

3. Work with the ocean recreation industry to inform visitors of use restrictions and traditional rights-of-way.

4. Encourage the ocean recreation industry to develop methods to address community concerns.

5. Identify additional areas where conflicts are occurring and develop restrictions to mitigate potentially hazardous conditions.

Policy H

Maintain resource quality and expand programs for enforcement of recreational resource use regulations.

Implementing Actions:

DOT, DLNR and DOH should:

1. Seek additional funding to increase enforcement capabilities of agencies involved in recreational resource management, including manpower, equipment, training and salaries.

2. Provide cross-training to ensure that each agency can enforce the other's regulations.

3. Clarify jurisdictional constraints to effective enforcement.

4. Develop a hotline for users to report violations of regulations and ensure timely response to complaints.

5. Analyze current hiring practices of enforcement personnel to ensure that DOT, DOH and DLNR officers are receiving similar training, pay and opportunities for advancement.

6. Educate users on resource restrictions.

DOT should:

7. Implement the Ocean Recreation Management Rules by installing buoys, posting signs and educating users about regulations.

Policy I

Develop a coordinated strategy of resource management that eliminates current jurisdictional overlaps or gaps.

Implementing Actions:

DLNR and DOT should:

1. Support the transfer of the Boating Branch from DOT to DLNR.

2. Re-evaluate the transfer of boating enforcement functions to the Department of Public Safety in favor of keeping these enforcement activities with the Boating Branch and transferring the Branch intact to DLNR.

Policy J

Develop agency advocacy for the marketing and promotional support of desirable ocean recreation industry sectors.

Implementing Actions:

DBED should:

1. Clarify the state's goals regarding tourism promotion and the support for the ocean recreation industry that services the tourist.

2. Develop a central permit process and work with other agencies to coordinate and expedite the commercial permit process ensuring that resource impacts are considered.

3. Identify desirable ocean recreation industry sectors.

4. Promote ocean recreation and sports industries through industry development and marketing support with emphasis on providing infrastructure for existing business.

   a. Identify sources of funding and other legal requirements necessary to start a business.

   b. Determine infrastructure needs, identify available infrastructure and work with agencies to increase infrastructure to meet demands.

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HARBORS

COMMERCIAL HARBORS

THE RESOURCE

Hawaii is completely dependent on its commercial harbor system for maintaining its economy and life-style. The State's heavy reliance on imported goods makes it imperative that the harbor system be maintained and improved. Nearly 98 percent of the goods imported into the State enter through the commercial harbor system, a statistic that has not changed significantly over time. The harbors are also the main distribution points for interisland shipping and commodity export. There are 11 commercial harbors operating throughout the Islands (ten State-operated and one privately-operated). There are also two offshore mooring sites for the off-loading of petroleum products for the oil refineries located at Barbers Point on Oahu.

Maritime pursuits have long been the largest and most stable of Hawaii's ocean industries. The industry posted revenues of $400 million in 1986 and employed 2,500 people, excluding military employment. Revenues were projected to grow by 34 percent to $534 million by 1990, while employing 2,750 people (MacDonald and Deese 1989). The two major sectors of the maritime industry are ocean transportation, and shipbuilding and repair. Ocean transportation includes shipment of cargo and petroleum products as well as passenger service. The volume of cargo entering the Islands also continues to grow. In 1988, 23.7 million tons of cargo — including foreign, domestic and interisland cargo — were handled at Hawaii's ports (COE 1988). Hawaii is primarily a destination point, where virtually all materials shipped into ports are for Hawaii itself; therefore, the volume of cargo will continue to increase as a function of increased population and economic growth. The rate of increase in imported cargo is estimated at two percent to three percent annually (DOT 1986).

The popularity of cruise ships as an alternative to the traditional resort vacation has continued to grow (DOT 1986). The cruise ship industry grew at an annual rate of 24 percent from 1981 to 1986, posting revenues of $59 million in 1986 (DBED 1989). Hawaii currently has two cruise ships homeported in the State and serve the Islands on a weekly basis. In addition, several trans-Pacific cruise ships make infrequent calls to the Islands and were expected to spend an estimated 20 boat-days in port during 1990 (DOT 1990a).

While there are no facilities in Hawaii capable of building large oceangoing ships, there are several private shipyards capable of providing maintenance and repair services. There are major marine repair plants at both Honolulu Harbor and Barbers Point. There are also major facilities at the Pearl Harbor Naval Shipyard. All of the private repair operations, except one, have waterfront facilities for the construction, repair and conversion of oceangoing vessels, tugs, towboats, dredges, barges and other vessels. At least two shipyards can handle vessels of 500-feet. The lift capacities of the floating drydocks range from 2,280 tons to 8,000 tons. The haul-out capacity of the marine railways ranges from 150 to 1,400 tons (COE 1987).

Economists project that United States trade among the Pacific nations will surpass trans-Atlantic trade by $40 billion in the year 2000 (DBED 1989). Many of these billions will be carried as marine cargo. Hawaii is poised to play a key role in handling this flood of trans-Pacific cargo. One strategic use of Hawaii's harbor resources is the State's bunkering facilities, which allow ships to refuel en route. Hawaii's Foreign Trade Zone is advantageous to shippers, who can save by only paying duty on their goods once they are moved from the zone into the United States. Hawaii is the only port equally accessible to all major markets on the Pacific Rim. It is equipped with a skilled labor force and terminal pier facilities that rank among the finest in the Pacific. It also has a growing ship repair industry. These factors point toward continued growth of the State's maritime industry (ibid).

Over 2,500 foreign-flag fishing vessels called at the Port of Honolulu between 1986 and 1988 to purchase fuel, provisions and other goods and services. The economic impact of these calls amounted to $46 million annually in direct expenditures. About half the amount came from tuna longliners and half from tuna motherships. These expenditures multiplied in the local economy to generate over $93 million in income annually (DBED/Sea Grant Program 1990a).

RESOURCE MANAGEMENT

Harbor Management

The Department of Transportation (DOT) is the lead agency for all harbor-related activities in the State. It is responsible for management of harbor operations. Chapter 266, HRS, gives DOT jurisdiction over harbor facilities owned or controlled by the State, and ocean waters and navigable streams. Chapter 267, HRS, covers boating matters such as vessel registration, equipment requirements and navigation safety.

A special fund (Harbors Special Fund), financed by harbor user fees, supports commercial harbor operations. Chapters 19-41 to 19-44 of the Hawaii Administrative Rules (HAR) apply to operations of commercial boat harbor facilities, including provisions concerning use and charges for facilities. Provisions on permits, small-craft owner responsibilities, safety, control of explosives and pollution also are included.

The U.S. Coast Guard, DOT Harbors Division, and Department of Health, Office of Hazard Evaluation and Emergency Response (HEER) are responsible for emergency response to oil and chemical spill incidences in harbors (see Waste Management Technical Paper).

Harbor Planning

For planning of commercial harbor development, responsibility lies with DOT's Statewide Transportation Planning Office. DOT is responsible for preparing a Statewide Transportation Plan, which includes harbors (Chapters 279A-2, 279A-3, HRS). A Statewide Transportation Planning Council has been established to coordinate the development of the Plan. It has the authority to approve for submission to the Legislature any project exclusively involving State harbors (Chapter 279A-7, HRS). Its membership includes representatives from State government agencies and each of the Counties (Chapter 279A-1, 279A-4, HRS). The Council, which meets quarterly, has the authority to determine the numbers and kinds of harbors in the State, in consideration of the following needs:

1) The preservation, safeguarding and enhancement of the physical and mental health of State residents, and the ecology and environmental quality of the State.

2) The need for high priority and vital movement of people and goods (Chapter 279A-9, HRS).

A master plan is prepared for each commercial harbor by DOT, Harbors Division, with projections to the year 2010. These have been prepared for Hilo, Kawaihae, Kaunakakai, Kahului,

Kaumalapau, Port Allen, Nawiliwili, Barbers Point Harbor and Honolulu Harbor. A master plan is in preparation for Kalaupapa. During the preparation of these plans, an ad hoc harbor advisory committee, consisting of harbor users, meets with the district manager and Harbors Division planning staff. Overlapping plans, such as the Honolulu Waterfront Master Plan, may be used for guidance. These master plans are updated on a continuous basis, and meetings of the harbor advisory committee take place at least once a year.

Harbor Construction and Maintenance Financing

For the most part, the State finances commercial harbor construction, either through the Commercial Harbors Special Fund or the General Fund. Hawaii also may float revenue bonds to support commercial harbor financing. The State must pay for all costs of shoreside facilities at commercial harbors, including finger piers, wharfs and other necessary shoreline construction.

Federal funds are available for dredging harbor entrance channels, turning basins and access channels and the construction of protective structures. These funds are administered through the U.S. Army Corps of Engineers (COE). Cost-sharing for these projects is approximately one-third State and two-thirds Federal. COE also maintains major navigation facilities, such as ship canals. Federal funds only are available for harbors that can be justified by commercial usage.

Harbor Construction Permitting

While commercial harbors are, for the most part, located within Special Management Areas (SMAs), they are exempt from County SMA requirements. DOT's authority over the planning, construction, operation and maintenance of harbor facilities does not require County approval for such projects (Chapters 266-2, 266-7, 205A-47, HRS). Nonetheless, environmental and social concerns are addressed through the coastal zone management (CZM) consistency review process.

Enforcement Responsibilities

State DOT exercises primary enforcement authority over use of harbor facilities and shipping operations within commercial harbors. The Coast Guard retains primary enforcement authority for commercial vessel inspection and other regulations governing non-recreational vessels.

MANAGEMENT ISSUES

Capacity of Commercial Harbors

Development of Hawaii's commercial harbor resources generally has been concentrated on landward infrastructure for cargo receipt, storage and transportation. Modernized cargo handling techniques and facilities have been helpful in managing the ever-increasing volumes of cargo at existing harbors. Adequate harbor facilities are critical to enable the increased import and export of cargo, to support currently expanding industries and to develop new industries.

With the increase in cargo coming into Hawaii's commercial harbors, the infrastructure at several harbors is inadequate to handle the added volumes. While the number of harbors is adequate, existing harbors need to be enlarged. DOT is currently engaged in a program of harbor facility expansion and improvements in accordance with the 2010 master plans for various harbors.

The revitalization of the cruise ship industry has added to this infrastructure overload, as cruise ships must compete with cargo vessels for wharf space at several of the smaller commercial harbors. Repair facilities for pleasure and cruise ships also are needed.

The rapidly growing local offshore longline fishing fleet is in need of increased dockage and pier space. Furthermore, basic dockside amenities — such as shower and sleeping facilities for the crews of foreign tuna longline-vessels reprovisioning in Hawaii — are not available in Honolulu Harbor. Development of such facilities by the private sector should be encouraged by the State in accord with the Honolulu Waterfront Master Plan. Opportunities for Hawaii's economic growth across multiple industries — including tourism, construction and agriculture — will be lost if the existing harbor system does not keep pace with changing and expanding needs.

Potential Environmental Impacts of Harbor Construction

Hawaii has only one natural harbor, Honolulu Harbor. Dredging, blasting and other physical alterations are necessary for the construction of any new facility. Most harbor dredging is accomplished through use of cutter-head or suction dredges, and use of silt curtains is a standard practice for dredging operations. Blasting is used only as a last resort. Such activities associated with harbor development and maintenance can cause environmental degradation. There are short and long-term environmental effects that must be considered in harbor construction. The siltation caused by dredging and blasting may affect the water quality, flora and fauna of the nearshore marine environment. In some coastal areas, construction activities have been linked, albeit tenuously, to the increase in the presence of ciguatera toxins in marine organisms.

Such alterations also may affect freshwater drainage patterns along coastlines. Depending on siting, harbor basins may require the destruction of some anchialine pools, wetlands or other habitats, thereby displacing species. Harbor construction may affect protected marine animals such as humpback whales and sea turtles.

Potential Environmental Impacts of Harbor Operations

Over time, harbor operations may impact the coastal and marine environments because of increases in noise, traffic and pollution. Marine mammals, sea turtles and adjacent reef flora and fauna may all be affected. Potential pollution problems are exacerbated by inadequate solid waste, oil and sewage disposal facilities in many harbors.

Accidental and operational releases of oil and other hazardous substances can threaten human health and the environment. Vessels calling on Hawaii's commercial harbors carry such substances as fuel and may also carry them as cargo. Emergency response and contingency plans and programs are needed for all commercial harbors.

Areal Constraints on Development

Harbor expansion and new harbor development can be impeded when appropriate lands have already been developed or are in private ownership. Desirable lands may also be designated for other uses, such as resort hotels, or classified as conservation areas and thus currently unavailable for harbor development.

Restrictions on Harbor Construction in Class AA Waters

New water-quality standards established by DOH are an additional constraint to harbor development. It is unclear if any commercial harbor construction will be allowed in Class AA waters, which include large sections of several Islands' coastal waters and virtually all of the Kona-Kohala coastline on Hawaii (Chapter 11-54, HAR).

RECOMMENDATIONS

Objective

Develop and maintain the State's commercial harbor system in order to meet both the needs of commercial users, and foreign and domestic commerce; and ensure that significant environmental and social impacts will be mitigated.

Policy A

Expand and improve the capacity of the State's commercial harbor system.

Implementing Actions:

DOT should:

1. Expedite the implementation of the 2010 Master Plan for each commercial harbor in cooperation with each harbor's advisory committee.

2. Incorporate mitigation plans for environmental and social impacts into the master plans for each commercial harbor.

3. Evaluate the effectiveness of the Statewide Transportation Planning Council in providing adequate interagency — in particular, effective County — participation and recommend any improvements.

4. Expand container facilities at Honolulu Harbor and other commercial harbors by rebuilding piers or building new piers, so they are able to accommodate modern cargo-handling facilities.

5. Encourage the private sector to develop basic dockside amenities for the crews of foreign tuna long-liners during re-provisioning stop-overs in Honolulu Harbor.

6. Work with the private sector and labor organizations to develop an expanded ship repair industry in Honolulu Harbor.

DOT, in cooperation with OSP, DBED, DB&F and the Counties, should:

7. Acquire areas needed for expansion and development of harbors, and designate other areas for future acquisition, particularly under-utilized areas.

Policy B

Minimize and mitigate impacts of harbor development and operations on ecological and cultural resources.

Implementing Actions:

DOT, DOH and DLNR, in cooperation with, UH, COE, and the Counties should:

1. Seek to instate comprehensive and on-going water quality and marine life monitoring programs for all existing and proposed commercial harbors in order to assess the environmental impact of harbor development and operations.

DOT, in cooperation with DOH, DLNR, NMFS, and COE, should:

2. Provide funding for research on the potential environmental impacts of commercial harbor development, including impacts on marine mammals and sea turtles, and the linkage between harbor construction and *ciguatera* poisoning in the area.

DOT should:

3. Improve dissemination of research and monitoring findings to the public so that community members can have a greater understanding and awareness of the impacts of commercial harbor development on the marine ecosystem.

SMALL BOAT HARBORS

THE RESOURCE

There are 18 small boat harbors and 50 boat launching ramps throughout the State which cater to recreational public and small commercial ocean recreation operators (DOT 1990a). Most of these small boat harbors are operated by the State. On Oahu, there are also small boat harbors operated by private groups and the military. Private boat harbors are being proposed as part of resort developments on most Islands. The unprecedented growth of the commercial ocean recreation sector and the number of personal boats have significantly increased the demand for additional small boat harbor facilities.

There are four repair facilities in the State which cater to small boats. These facilities, located at Honokohau, Keehi, Kewalo Basin and Ala Wai, have haul-out capabilities ranging from 35 to 70 tons. As a whole, the direct gross revenue generated by the different subsectors servicing recreational boaters in 1989 was estimated at approximately $58 million (DBED/Sea Grant Program 1990b).

RESOURCE MANAGEMENT

Harbor Management

DOT is the lead agency for all harbor-related activities in the State. It is responsible for management of harbor operations. Chapter 266, HRS, gives DOT jurisdiction over harbor facilities owned or controlled by the State, and ocean waters and navigable streams. Chapter 267, HRS, covers boating matters such as vessel registration, equipment requirements and navigation safety. DOT, Harbors Division, issues commercial permits for use of boat ramps and small boat harbor facilities, and assesses fees of 2 percent of gross revenues for their use.

The Boating Special Fund finances management operations for small boat harbors and launching ramps. Its sources of revenue include harbor user fees, the State marine fuel tax and income from leases of boat harbor properties. Other financial assistance for boating safety equipment and programs is available from the Federal government. DOT manages most boat launching ramps, and recreational boaters use these ramps free of charge. In a few cases, such as the Laupahoehoe boat ramp on Hawaii, the County Parks and Recreation Department manages the ramps. Operation of boats within small boat harbors is regulated by Chapters 19-61 to 19-66 of the Hawaii Administrative Rules.

Harbor Planning

Planning for small boat harbors is done primarily by DOT, Harbors Division. For the most part, it is done on a near-term basis, rather than long-range. Until 1976, there was a Governor's Advisory Committee on Harbors and Ramps, which was involved in small boat harbor planning. A Governor's Ad Hoc Boating Task Force was established in 1981 to advise DOT on priorities for boating facility expansion and construction. The Task Force was disbanded in 1983 after the recommendations were submitted to the Governor. These recommendations have been used as the basis for small boat harbor project development ever since, subject to Legislative appropriations to implement these projects.

For private marina proposals, the permit process includes approvals from Office of State Planning (OSP), DOT and DLNR, among others. DOT recently has prepared a planning report on recreational marinas to assist in the planning efforts (DOT 1989a). This report covers DOT, Harbors Division, policies and practices, required permits, an overview of demand for marina facilities, and an inventory of public and private marina facilities. OSP has drafted a policy on marina development.

Harbor Construction and Maintenance Financing

Small boat harbor construction and maintenance are financed, to a large extent, by the Boating Special Fund. As with commercial harbors, the State must pay all costs for shoreside facilities.

Other Federal funds that are available for boating programs and facilities come through mechanisms put in place by the Wallops-Breaux Act. The Aquatic Resources Trust Fund established by the Wallops-Breaux Act consists of the Boating Safety Account and the Sport Fish Restoration Account. The Boating Safety Account receives the initial deposit of Federal marine fuel taxes as appropriated by Congress each year ($70 million for FY 1991); the next $1 million goes to the Land and Water Conservation Fund; and the balance is deposited to the Sport Fish Restoration Account. Of the $70 million, half goes directly to the Coast Guard to help defray expenses incurred in support of boating safety efforts, and the other half is distributed to individual states to augment their boating safety efforts.

The Sport Fish Restoration Account also receives all the revenue formerly derived through the Dingell-Johnson Act (including the excise taxes on fishing equipment). A minimum of ten percent of each State's allocation is mandated to be used for boating access construction. DLNR is the recipient of Hawaii's allocation of Sport Fish Restoration funds, and DOT applies for use of these funds through DLNR. Each project must be approved on a case-by-case basis by the U.S. Fish and Wildlife Service (FWS).

Harbor Construction Permitting

Small boat harbors that are DOT public facilities are exempt from County SMA requirements. COE is the primary permit-granting agency at the Federal level, and DLNR is the primary permitting authority at the State level through the Conservation District Use Application (CDUA) process. COE and DLNR circulate permit applications to respective Federal and State agencies for review and comment: DOH for impacts on water quality; U.S. National Marine Fisheries Service (NMFS) for impacts on marine mammals and fisheries; FWS for impacts on turtles and seabirds; and U.S. Environmental Protection Agency (EPA), if a Federal Environmental Impact Statement (EIS) is required. The State Coastal Zone Management Program is responsible for determining whether proposals are consistent with the State Coastal Zone Management Act. In this way, permit application reviews may proceed concurrently.

DOT generally supports proposals for the construction of private small boat harbors. A streamlined permit system has been established through Chapter 171-60, HRS, for joint public-private ventures. Public land leases have been issued in the past to private individuals or interests for the development and operation of private marinas on State lands (DOT 1989a).

Enforcement Responsibilities

DOT exercises primary enforcement authority for boating safety over non-commercial vessels (Chapters 26-19, 266-1, HRS). State and the Coast Guard have joint enforcement responsibili-

ties for all charter and tour boat operations. The State considers these recreational although they are subject to commercial licensing. The Coast Guard considers them commercial because they provide services for hire.

MANAGEMENT ISSUES

Inadequate Supply of Small Boat Harbor Facilities

Existing small boat harbor slips in Hawaii only accommodate a small percentage of the demand for such slips. According to the waiting lists maintained by DOT (which officials agree under-represent actual need), existing slips meet approximately 44 percent of the need. As of March 31, 1990, there were approximately 2,600 recreational vessels statewide on waiting lists for slips at small boat harbors (DOT 1990b). There is also a proliferation of offshore moorings and anchorages for the estimated 2,000 or more boats that cannot get slips in harbors. Some of these moorings and anchorages are illegal. These statistics are evidence of an inadequate supply of slips in small boat harbors.

There were approximately 14,857 boats registered in the State as of March 1990 (DOT 1990b). Of 2,075 slips existing in the State, 1,802 are in use (DOT 1990b). Vacant slips are empty for only a short time and often are filled by transient vessels in the interim between long-term moorages.

The demand for additional harbor facilities is growing because of an expanding commercial ocean recreation industry and an increased interest in boating by the general public. The inadequate supply of harbor facilities and launching ramps has fostered competition between individual ocean recreation users and commercial recreation operations for the limited spaces available. While dry-stack storage facilities provide a useful alternative to permanent slips, there is only one such facility in the State.

In addition to increasing the number of ramps, slips and dry-stack storage and associated facilities, the harbors' restrooms, showers, wash-down facilities, trash collection cans, and facilities for disposal of oil and sewage also should be improved. The development of more small boat harbor facilities is needed if opportunities for growth in the ocean recreation industry are to be realized.

Another difficulty which must be addressed is public opposition to many small boat harbor developments. Plans for new boat harbors at Lahaina, Heeia Kea and Hanalei were defeated by opposition from the local communities. The "Not in My Back Yard" (NIMBY) syndrome also applies to plans for new launching ramps at various locations throughout the State.

Maintenance of Existing Harbor Facilities

In some small boat harbors, facilities such as restrooms, ramps and waste receptacles are not well-maintained. Without proper cleaning, ramps can become extremely slippery. In some harbors throughout the State, docks are broken, cracked or sinking, and cleats are broken. Solid waste, oil and sewage disposal facilities need to be improved, and public education programs regarding their use developed. Improved tender facilities and dinghy docks also are needed on the Neighbor Islands. Because harbor user fees are low and ramp user fees nonexistent, the maintenance budget for small boat harbors and ramps is relatively small in terms of total dollars spent. However, the budget is relatively big, considering its percentage of the overall operating budget for the boating program.

Conflicts Among Harbor Users

The growth of the commercial recreation industry, especially the tour boat industry, has resulted in increased shortages of harbor space. It also has brought about long lines to launch both private and commercial recreational boats at popular boat launching ramps. Commercial tour boats operate out of commercial and small boat harbors alike, depending on size and location. The public has expressed concern about the use of small boat harbors for commercial recreation activities, and the lack of available slips has exacerbated this issue.

The construction of small boat harbors and the increase in boat traffic from new harbors may cause conflict between boaters and other users of these areas, such as fishermen, divers, swimmers and surfers. Harbors can also impede lateral coastal public access along the shoreline, or provide increased access. These issues usually are addressed during the SMA permit process. However, since DOT harbor construction is exempt from this County requirement, the issues are addressed in other forums.

Small Boat Harbor Funding

Inadequate funding for harbor development is the biggest hurdle to development of small boat harbors in the State. Harbor development is very costly. Estimates for construction costs of building one small boat harbor slip are in the range of $70,000. Since COE only covers the cost of dredging and breakwater construction, the remaining financial burden falls on the State. Also, Federal matching funds to develop harbor facilities are not available for strictly recreational harbor facilities. Other financing arrangements are needed, such as a modified user-fee structure. In addition, when funds are available, it is often on a phased basis, so that small boat harbor construction is not completed in an expeditious manner.

The State has a policy that facilitates privatization of small boat harbor development (Chapter 171-60, HRS). Under this statute, negotiated leases of public lands are feasible. Chapter 171-59(b), HRS, requires that the disposition of submerged lands by negotiation be for the purposes of: 1) encouraging competition in maritime industries and 2) limited to a period of 35 years (DOT 1989a). Legal review of each lease proposal is conducted before final determination is made regarding method of disposition. Basic policy dictates that leases should be

offered for public auction to avoid giving any specific party preferential consideration. DOT also is pursuing the Request For Proposal (RFP) method for disposal of the lease of the Pier 60 area in Keehi Lagoon for private development. This method may be selected for proposed leases for private marina development on State lands in the future.

If private marina developers cannot negotiate with the State and be assured of the rights to development, they have little incentive to spend the necessary capital to prepare the appropriate proposals to meet the various requirements for the project.

Potential Environmental Impacts of Harbor Construction

Hawaii has only one natural harbor, Honolulu Harbor. Dredging, blasting and other physical alterations are necessary for the construction of any new facility. Most harbor dredging is accomplished through use of cutter-head or suction dredges, and use of silt curtains is a standard practice for dredging operations. Blasting is used only as a last resort. Such activities associated with harbor development and maintenance can cause environmental degradation. There are short and long-term environmental effects that must be considered in harbor construction. The siltation caused by dredging and blasting may affect the water quality, flora and fauna of the nearshore marine environment. In some coastal areas, construction activities have been linked, albeit tenuously, to the increase in the presence of ciguatera toxins in marine organisms.

Such alterations may also affect freshwater drainage patterns along coastlines. Depending on their site, harbor basins may require the destruction of some anchialine pools, wetlands or other habitats, thereby displacing species. Harbor construction may affect protected marine animals, such as humpback whales and sea turtles.

Potential Environmental Impacts of Harbor Operations

Over time, harbor operations may impact the coastal and marine environments because of increases in noise, traffic and pollution. Marine mammals, sea turtles and adjacent reef flora and fauna may be affected. Potential pollution problems are exacerbated by inadequate solid waste, oil and sewage disposal facilities in many harbors.

Accidental and operational releases of oil and other hazardous substances can threaten human health and the environment. Many fuel docks in small boat harbors do not have adequate equipment for spill prevention and clean-up.

Coordinated Planning for Harbor Development

Since the Governor's Advisory Committee on Harbors and Ramps is no longer in existence and the Statewide Transportation Planning Council is not responsible for small boat harbor planning, there is no State interagency planning body focusing on small boat harbor issues. In addition, there is no comprehensive plan for public and private small boat harbor development in Hawaii. Consequently, statewide planning for expansion and development of small boat harbors is poorly coordinated.

Interagency efforts to evaluate harbor proposals also are not well coordinated. Such coordination is essential because of its potential to diffuse conflicts that occur during, or as a result of, harbor development. Cooperation affords improved planning and management opportunities for the involved government agencies and communities. Community involvement may make residents more receptive to harbor development projects. Cooperation also enables the agencies to identify and address the many overlapping impacts of harbor development, including potential conflicts with other coastal uses, such as fishing, surfing and diving.

There is no clear overall State policy on private marina development at this time, though OSP is formulating one. Currently, each marina proposal is handled on an ad hoc basis, without any guidance from a comprehensive plan. DOT has emphasized the need for a general plan outlining the location, development and prioritization of marinas and launching ramps (DOT 1989a). Public use of private ramps and slips must be considered during this planning process.

Areal Constraints on Development

Harbor expansion and new harbor development can be impeded when appropriate lands already have been developed or are in private ownership. Desirable lands also may be designated for other uses, such as resort hotels, or classified as conservation areas and thus currently unavailable for harbor development.

While there is a push to build new harbors and expand existing ones, the potential for overcrowding must be considered. Already, crowded conditions exist in some harbors. Due to Hawaii's strong winds, large open ocean swells and rough waters, areas along the leeward coasts and in more protected nearshore waters and bays traditionally have been the focus for harbor development. More recently, resort areas also have been a focus for harbor development. There is a need to consider innovative ways to develop coastal areas where little boating occurs.

Restrictions on Harbor Construction in Class AA Waters

Water-quality standards established by DOH are an additional constraint to harbor development. It is unclear if any small boat harbor construction will be allowed in Class AA waters, which include large sections of several Islands' coastal waters and virtually all of the Kona-Kohala coastline on Hawaii (Chapter 11-54, HAR).

RECOMMENDATIONS

Objective

Develop and maintain the State's small boat harbor system in order to meet the needs of recreational and small commercial vessel users in ways that ensure significant environmental and social impacts will be mitigated and local carrying capacities will not be exceeded.

Policy A

Expand the State's small boat harbor system, including launching ramps, taking into account analyses of the areas' carrying capacities and the economic efficiency of proposed harbors.

Implementing Actions:

DOT should:

1. Request that the Governor revive the Governor's Advisory Committee on Harbors and Ramps and charge them with providing recommendations for a statewide master plan for small boat harbors and private marinas. Membership on this committee should be limited to those with direct interest in the boating industry and community.

2. Based on recommendations of the Governor's Advisory Committee on Harbors and Ramps, prepare a statewide comprehensive plan for recreational public boat harbors, and private resort-based marinas. This plan should include: assessment of the requirements of private recreational boaters and the commercial recreation industry; comparison of benefits between clustering and dispersing marinas along coastlines; statewide survey of possible sites on public shorelines and private property, and identification of possible locations for harbors of refuge.

3. As part of this planning process, encourage workshops with the local user communities and studies of the area's environmental and social characteristics, including carrying capacities of the surrounding areas.

4. Formulate a comprehensive State policy regarding development of private marinas. [OSP is currently developing such a policy and this should be done in cooperation with DOT, DBED, Counties and the Governor's Advisory Committee on Harbors and Ramps.]

5. Consider public need through the allocation of a certain number of slips to the public, or allow public use of the launch ramps and parking within or near private resort marinas.

6. Consider increasing the maintenance budget for small boat harbors, and consider financing this through an increase in user fees.

7. Establish an equitable user fee structure for all users of public small boat facilities. This may include charging fees to all users, including those using the launching ramps. The money from these users would continue to go directly to small boat harbor improvements.

8. Organize harbor user groups to clean up harbor facilities on a periodic basis. This would include boaters and private operators of harbor concessions.

9. Promote the development of more launching ramps and dry-stack storage units with public funds and in partnership with private companies.

10. Provide more launching ramps and parking areas for commercial recreational boat users within the metropolitan Honolulu area.

11. Work with the private sector to expand facilities for ocean yacht racing.

Policy B

Minimize the conflicts between harbor development and other ocean and coastal activities.

Implementing Action:

DOT should:

Increase the use of existing harbor advisory panels and establish such panels in harbors where they do not currently exist. (These panels are in addition to the Governor's Advisory Committee on Harbors and Ramps [see Policy A, Action 1].)

Policy C

Facilitate public-private partnerships and other alternative means for financing harbor development.

Implementing Actions:

DOT should:

1. Develop provisions for government incentives to induce private-sector investment in: marina infrastructure development; shore-based small boat storage facilities; and shoreline parks and park facilities.

2. Expedite development of the boat slips and offshore mooring areas currently proposed and critically needed.

DOT, in cooperation with OSP, DBED, and DB&F, should:

3. Formulate strategies to finance facilities that support economically valuable ocean-related or harbor industries (e.g., ship repair and construction, and small boat industries). Possible funding sources include the Federal government, the State General Fund, and the private sector.

Policy D

Minimize and mitigate impacts of harbor development and operations on ecological and cultural resources.

Implementing Actions:

DOT, DOH and DLNR, in cooperation with UH, COE, the Counties, and private marina developers, should:

1. Seek to instate comprehensive and on-going water quality and marine life monitoring programs for all existing and proposed small boat harbors in order to assess the environmental impact of such harbor development and operations.

DOT, in cooperation with DOH, DLNR, NMFS, and COE, should:

2. Provide funding for research on the potential envi-

ronmental impacts of small boat harbor development, including impacts on marine mammals and sea turtles, and the linkage between harbor construction and *ciguatera* poisoning in the area.

DOT should:

3. Clarify with DOH the specific requirements for constructing marinas in Class AA waters.

4. Improve dissemination of research and monitoring findings to the public so that community members can have a greater understanding and awareness of impacts of small boat harbor development on the marine ecosystem.

5. Require that all private and public small boat harbors have facilities for disposal of sewage and oil, and that small boat harbors and launching ramps have receptacles for solid waste disposal, including separate receptacles for recyclable materials. Educational materials should be developed and disseminated. [See Waste Management section.]

6. Establish a comprehensive education program to make boaters aware of the importance of using disposal facilities for sewage and oil, and of bringing solid waste - including plastics - back to shore for proper disposal.

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FISHERIES

THE RESOURCE

Hawaii has a wide range of fisheries resources that are exploited for subsistence, recreational, and commercial purposes. These include reef and nearshore species, bottom fish, lobsters and other crustaceans, and pelagic fish including several species of tuna. There are two principal fishing regimes in the State: 1) inshore and nearshore fisheries and 2) offshore fisheries. The two regimes have markedly different resource characteristics, levels of abundance and potential for increased exploitation.

Hawaii's inshore and nearshore fisheries resources are very limited compared to offshore resources. They include a wide variety of marine organisms that are exploited largely for subsistence and recreational use in the main Hawaiian Islands. Although there are very limited data on these resources, it is widely recognized that inshore resources in the main Hawaiian Islands have been in decline for many years (NMFS 1987; Lee 1990).

Inshore resources are harvested using nets, spears, and pole-and-line. However, data on the number of individuals using these fishing methods, the amount of effort they expend and the amount of fish caught are not available for the State as a whole. Nevertheless, it is widely recognized that the number of people participating in the inshore and nearshore fisheries is very large compared to the offshore fisheries. One estimate indicates that in 1980, recreational shore fishermen made 1.4 million fishing "trips," roughly twice the number of "trips" made by private boats and charter vessels (NMFS 1990a).

While the total extent of Hawaii's offshore fisheries resources is difficult to assess, annual sustainable yields of fish in Hawaii's waters could be as high as 43 million pounds per year, a substantial resource for the State (PBDC 1983). Reliable data on the current level of fishing are not available. However, the National Marine Fisheries Service (NMFS) estimates that approximately 20 million pounds of locally caught fish were marketed in Hawaii in 1988 and valued at $42 million. There were approximately 1,896 registered fishing vessels in Hawaii; 1,156 are State-registered and the balance are Federally documented vessels. It is estimated that 525 of the 1,896 total are full-

time commercial vessels. The latter includes boats used by a percentage of the 2,770 registered fishermen who fish on a part-time basis (Bourke and Markrich 1990). In addition, an estimated 1,156 of the 14,250 "non-documented" vessels were used for commercial fishing in Hawaii as of January 1, 1989 (Bourke and Markrich 1990).

Hawaii's commercial fleet has experienced considerable growth in the past two years. The major component of that growth is the longline fleet, which increased from about 50 vessels at the end of 1988 to about 100 during the second quarter of 1990. Catch statistics indicate that landings of pelagic fish (tuna, billfish, *mahimahi* and *ono*) increased from an estimated 12.8 million pounds in 1987, to 16.3 million pounds in 1989 (NMFS 1990b). The major landings in 1989 included 10.5 million pounds of tuna, 5.4 million pounds of billfish, *mahimahi, ono,* and other species, and 275,000 pounds of other pelagics (NMFS 1990b). The most dramatic increase in catch since 1988 has been in swordfish. Swordfish landings have increased from 50,000 pounds in 1988 to over 2.5 million pounds during the first five months of 1990 (WESTPAC 1990e). The Western Pacific Regional Fishery Management Council estimates that without some limit on the number of boats entering the fishery, the longline fleet could grow to as many as 150 vessels in the near future (WESTPAC 1990j).

In 1988, an estimated 2.28 million pounds of bottomfish worth $6 million were landed (WESTPAC 1989h). The majority of the 1988 catch of 1.7 million pounds was in the main Hawaiian Islands where NMFS estimates a maximum sustainable yield of only 627,000 pounds (WESTPAC 1989b). The latest information available indicates 1,050 vessels sold a portion of their bottomfish catch in 1989: the main Hawaiian Islands fleet harvested approximately 1.2 million pounds of bottomfish valued at almost $3.9 million in 1989. A total of 10 boats participated in the Northwestern Hawaiian Islands (NWHI) bottom fishery in the same year. Landings totaled 303,000 pounds and yielded an ex-vessel revenue of about $756,000 (WESTPAC 1990g).

The size of Hawaii's lobster fleet has varied considerably since 1980. As many as 16 and as few as three vessels have participated in the NWHI's lobster fishery. In 1989, a total of 1.2 million pounds of spiny lobster and 184,000 pounds of slipper lobster were caught by 11 vessels. The combined value of the NWHI lobster catch in 1989 was $6.3 million (NMFS 1990c).

The number of vessels harvesting deep sea shrimp also has fluctuated in the last decade. Currently, one vessel is actively fishing for *ono* shrimp on a full-time basis. Catch statistics are not available from that boat. However, industry sources indicate that several thousands of pounds of shrimp have been harvested in single trips of a month or so. There are several smaller boats landing both *ono* and spotted shrimp. The estimated landings for these boats in 1987 include 10,000 pounds of shrimp worth $42,000 and 800 pounds of spotted shrimp valued at $2,000 (WESTPAC 1989b).

Six beds of precious corals have been identified in the Hawaiian Islands: one off Makapuu Point, one off Kaena Point, one off Keahole Point, and three in the NWHI. The Makapuu bed is the only one of the six that has been studied systematically. During a six-year period in the 1970s, approximately 17,500 kilograms or almost 8,000 pounds of pink, gold or bamboo coral were harvested (WESTPAC 1990h). It is estimated that this was about 40 percent (by weight) of the standing stock (WESTPAC 1990h; 1990i). Between 1983 and 1987, divers reported harvesting 11,000 pounds of black coral, although this is probably much less than the amount actually taken (WESTPAC 1989b). Moreover, there also have been allegations of poaching of precious corals by foreign fishing vessels in the NWHI.

The State's recreational fisheries have an estimated intrinsic value of over $200 million (NMFS 1990a). Approximately, 2,627 people were employed in commercial fishing in 1988 (Shannon 1990). Although no recent statistics are available on revenues and employment in seafood marketing associated with commercial fishing, retail sales of fish (locally caught and imported) in the State totaled approximately $116 million in 1986 over and above the ex-vessel value of the fish. In addition, seafood marketing employed approximately 2,100 people (MacDonald and Deese 1989). Seafood sales are expected to reach $176 million in 1990 and provide employment of about 2,700 people (ibid). Revenues in charter boat fishing and international fishing tournaments alone total an estimated $10 million to $12 million (ibid).

RESOURCE MANAGEMENT

Regulation and Enforcement

Hawaii's fisheries are managed by both the Federal government and the State of Hawaii. Fisheries within State waters of the main Hawaiian Islands are managed by the State Department of Land and Natural Resources (DLNR) through its Division of Aquatic Resources (DAR). Enforcement of State fishing regulations is provided by the Division of Conservation and Resources Enforcement (DOCARE) with 72 officers (1989). Fisheries resources surrounding the NWHI are managed by DAR and the Federal government through NMFS and the Western Pacific Regional Fishery Management Council (WESTPAC). A State Commercial Marine license with a Northwestern Hawaiian Islands Taking Permit is required to take, catch, possess, sell or offer for sale certain marine life or use certain gear in the NWHI. Enforcement of Federal fisheries regulations as well as the Marine Mammal Protection Act and the Endangered Species Act are the responsibility of NMFS, the U.S. Fish and Wildlife Service (FWS), and U.S. Coast Guard.

Federal Authority

Federal regulation and management of fisheries in Hawaii are conducted under the authority of several Federal statutes. The Magnuson Fisheries Conservation and Management Act (FCMA) charges WESTPAC, and seven other regional councils around

the country, with the responsibility of developing fisheries management plans. WESTPAC and NMFS are required, under Federal statute, to develop management plans and regulate fishing within the 200-nautical mile Exclusive Economic Zone (EEZ) surrounding the U.S. islands in the Pacific. Enforcement of Federal fisheries regulations is provided by NMFS' Southwest Enforcement Office and the Coast Guard.

There are four management plans for the WESTPAC region, which includes Hawaii, American Samoa, Commonwealth of the Northern Mariana Islands and Guam. WESTPAC has developed regional plans for lobster, bottomfish, pelagic species (except for tuna), and precious corals. Lobster fishing regulations require permits and catch, fish processing, and sales reports. They also restrict catch area, minimum size, daily catch, trips, processing, sales and gear. Federal regulations for bottomfish limit entry into certain areas of the NWHI and prohibit the use of trawl nets, bottom gill nets, explosives and poisons. The limited access program was instituted by WESTPAC for the NWHI bottom fishery in 1989 because there was evidence of over fishing (WESTPAC 1990g). Commercial catch of bottomfish in Federal waters also must be reported to the State. Federal regulations governing pelagic species place geographic restrictions on foreign fishing in Hawaii, prohibit the use of drift gill nets, require permits and fishing logs for longlining, and reporting of incidental catches of turtles and marine mammals.

State Authority

State fisheries are regulated through both statutes and administrative rules. State regulations impose minimum size, gear type, bag limits, and/or fishing season restrictions on over 20 species of reef, lagoon, and bottomfish species as well as octopus *(tako)*, limpet *(opihi)*, and several varieties of crabs and lobsters. These regulations prohibit the taking of live stony corals, clams, oysters, and other shellfish, sea turtles, and monk seals, and restrict fishing in 23 harbors and designated marine life conservation districts. The State prohibits the use of drift gill nets, and fishing with explosives, electro-fishing devices, poisons, intoxicants and chemicals (DLNR/DAR 1990). The State also prohibits the possession of drift gill nets on boats calling at ports in Hawaii.

State regulations require licenses for commercial fishing. A total of 2,770 commercial fishing licenses was issued in 1989. Fishermen with commercial licenses are required to file monthly catch reports. Neither licenses nor catch reports are required for saltwater recreational fishing. Reporting requirements are monitored by DAR. Marine safety regulation and enforcement is vested with the Hawaii State Department of Transportation (DOT) and the Coast Guard.

Hawaii requires a Special Marine Animal or Product Possession and Sale License for the commercial sale or serving of lobsters, Kona crabs, *moi*, and mullet during their respective closed season periods. A Scientific Collecting Permit is required to take, possess or sell certain species of aquatic life using certain kinds of restricted gear or in restricted areas. People also may apply for permits to take, possess or sell certain species of oyster and clam as well as top shell, abalone, or quahog. Freshwater game fish licenses are required by the State for recreational fishing in lakes, streams and rivers. Permits also are required for use of small mesh nets and traps to stock home aquariums with marine tropical fish from Hawaiian waters.

Monitoring and Research

Federal Support

NMFS has compiled and analyzed fisheries statistics of the western Pacific, including Hawaii, on an annual basis. These statistics are based on the commercial fisheries catch data gathered by DAR. In addition, NMFS and DAR gather wholesale marketing statistics which are used in part to monitor fishing activity in the State. NMFS has also gathered vessel cost data on the Northwestern Hawaiian Islands lobster and bottomfish fisheries for economic analysis. NMFS provides reports on its studies to WESTPAC to meet its responsibility for review of fisheries it manages.

WESTPAC, as part of its regional fisheries management responsibility, commissions studies to facilitate the development of fisheries management plans (FMPs). Studies also are commissioned by WESTPAC, like those conducted by NMFS, to assess the status of fisheries resources for which the Council has developed plans. WESTPAC's annual reports are compiled with reference to the FMPs for pelagic species, precious corals, bottomfish and lobster, and contain regional resource assessments for each FMP.

State Support

DAR gathers and compiles catch statistics for commercial fishing in the State. Commercial fishermen are required by State law to report their catch to DAR. A standard Fish Catch Report, which includes information on the area fished, type of gear used, as well as species, number, weight, and sales of fish caught, is used to report catch. Other forms are used for specific fisheries, including tuna pole-and-line fishery, and longline fishery.

DAR, in cooperation with the NMFS, FWS and the University of Hawaii Sea Grant College Program, has funded the Hawaii Cooperative Fisheries Research Unit, Oceanic Institute, Hawaii Institute of Marine Biology, and other agencies to conduct specific studies to address resource management problems. In 1988, a five-year Main Hawaiian Islands Marine Resources Investigation (MHI-MRI) was initiated involving most of these agencies and organizations. The purpose of the study was to address increasing concerns over Hawaii's nearshore fisheries resources, the habitat and environment, and competing nearshore activities (DLNR/DAR 1989a; DLNR 1989).

Infrastructure Development

Federal Programs

There are several Federal and Federally funded fisheries development programs that serve the State (Shannon 1990). The

National Industrial Recovery Act, known as the Saltonstall-Kennedy (SK) program, provides funding for fisheries development projects. The majority of SK funding has been channeled through the Pacific Fisheries Development Foundation, which supports fisheries development projects in Hawaii and the other American Flag Pacific Islands as well as the Federated States of Micronesia, Republic of the Marshall Islands, and Palau. However, the amount of SK funding available has declined significantly in recent years. In addition, the Commercial Fisheries Research and Development Act and the Federal Aid in Sport Fish Restoration Act (Dingell-Johnson Act) provide Federal funding for fisheries management and projects.

Coordination of local and regional efforts aimed at fisheries development and management is facilitated through the Marine Fisheries Advisory Committee (MAFAC). Changes in Federal legislation and regulations, as well as efforts aimed at fisheries management and development, are facilitated though MAFAC, which has a representative from the Western Pacific region.

State Programs

DOT's Harbors Division is involved in fisheries infrastructure development through harbor development, management and maintenance in support of Hawaii's commercial and recreational fisheries. Harbors Division has responsibility for ten major commercial harbors and numerous small boat harbors and boat launching ramps. There were 18 small boat harbors and 50 boat launching ramps at the end of 1989 (see Harbors Technical Paper).

DAR supports recreational fisheries through the deployment and maintenance of fish aggregation devices (FADs). As of June 1990, the FAD system consisted of 55 surface FADs and 22 mid-water FADs in waters surrounding the main Hawaiian Islands (DLNR/DAR 1990). The statewide FAD system resulted in catches totaling 904,667 pounds in 1989 (Shannon 1990).

Trade and Investment Promotion

Federal Support

In the past, the Pacific Basin Development Council (PBDC), an economic development organization made up of the Governors of American Samoa, Commonwealth of the Northern Marianas, Guam and Hawaii, has assisted the American Flag Pacific Islands (AFPI) with fisheries infrastructure planning. Currently, PBDC is assisting AFPI in assessing trade policies that may inhibit trade and investment in fisheries and other sectors.

The International Trade Administration (ITA) of the U.S. Department of Commerce supports the export of products, including seafood, from the United States. The ITA and NMFS provide market information to assist the development of fisheries exports in the State.

State Support

The Ocean Resources Branch (ORB) of the State Department of Business and Economic Development and Tourism (DBED) is the principal agency responsible for ocean industry development in Hawaii. ORB is involved in the promotion of investment in commercial fisheries development. ORB runs the State's seafood marketing program to promote the development of under-utilized fisheries resources and encourages substitution for high-demand species. ORB also conducts economic assessments of fishery-related activities such as fishing tournaments, personal boating and provisioning by foreign fishing fleets. It also promotes marine tourism development in Hawaii. The Financial Services Branch of DBED administers a large fishing vessel and a small fishing vessel loan program to support the purchase, renovation, maintenance and repair of vessels. Currently, fishing boat loan funds are being used primarily to purchase new longline gear and for vessel maintenance.

MANAGEMENT ISSUES

Management issues associated with the fisheries sector in Hawaii fall into five major categories: 1) resource sustainability, 2) user conflict, 3) lack of financial resources for fisheries development; 4) Native Hawaiian rights; and 5) ineffective management and inter-agency coordination.

Resource Sustainability

Some of Hawaii's fisheries resources have declined in abundance, apparently as a result of over-exploitation and environmental degradation. The number of people who participate in recreational and commercial fisheries in the State has increased with the growth of the State's population (DLNR/DAR 1988a). The impact of increased exploitation has been particularly devastating for inshore and nearshore fisheries resources (Lee 1990). Although there are no comprehensive data on nearshore fisheries for the State as a whole, most fishermen and scientists agree that the inshore areas around the main Hawaiian Islands have been seriously "over-fished." Some would argue that environmental pollution has contributed to the decline of in- and nearshore fisheries resources. However, the recovery of reef fisheries in marine life conservation districts that have been closed to fishing indicates that restricting fishing can greatly help to restore depleted resources (Lee 1990; NMFS 1987).

Corals in specific locations around the main Hawaiian Islands have suffered considerably from habitat degradation (United Nations Environmental Programme 1988). Channel blasting, siltation and other forms of pollution have resulted in declines of coral populations on reefs in Waikiki, Honolulu Harbor, parts of Lanai and Molokai, and other locations in the State (ibid). Coral populations in Kaneohe Bay also suffered decline from pollution but are recovering after new pollution controls and management measures were instituted. Illegal harvesting of reef corals for souvenirs and use in aquariums probably has had an impact on coral populations in certain areas. And, the use of anchors by fishing and pleasure boats has damaged coral reefs in certain areas. Declines in coral populations resulting from pollution and these other activities prob-

ably have had an impact on reef fish populations that depend directly or indirectly on coral for food and shelter.

Precious corals, including pink, gold or bamboo coral, have been found in deep water in several locations throughout the Hawaiian archipelago. Precious corals have been subject to poaching by foreign vessels within the 200-nautical mile EEZ of the NWHI. The only regular commercial exploitation of precious coral run by a domestic operator lasted for six years during the 1970s. However, high operating costs and foreign competition resulted in the termination of this operation. Research indicates that despite the slow growth of precious corals, limited commercial exploitation could be sustained if it were economically feasible (WESTPAC 1990i).

There are no systematic studies of the status of black coral populations in Hawaiian waters. Black coral harvested between 1983 and 1987 was in excess of 11,000 pounds. Moreover, there are reports of divers taking small colonies for sale to curio dealers and interior decorators (WESTPAC 1989b). There are no regulations restricting harvests of black corals. According to State officials, black coral populations are currently not over-exploited. However, there are some people who think black corals are being over-exploited.

Lobster and bottomfish fisheries are particularly susceptible to over-exploitation because of their limited habitats in Hawaii. Commercial exploitation of both fisheries can lead to significant declines in catches, and, if not properly managed, can cripple them (WESTPAC 1988). Because both are exploited commercially in the NWHI at considerable distance from centers of population, they are to some degree self-regulating. When catch-per-unit-of-effort drops below a certain point, fishermen find it no longer profitable to participate in these fisheries because of high operating costs. However, this "economic" regulation of the lobster and bottomfish fisheries does not maximize the value of the resources and causes hardship to individual fishermen. A limited-entry program is in effect to address this problem for bottomfish for a portion of the NWHI. An assessment is being conducted by WESTPAC to determine the need to limit effort in the NWHI lobster fishery (WESTPAC 1990b). In 1989, the NWHI lobster fishery experienced a significant increase in fishing effort, and the catch-per-unit-of-effort declined (NMFS 1990c).

There is concern that the maximum sustainable yield (MSY) for bottomfish species in the main Hawaiian Islands is seriously being exceeded. As indicated, NMFS estimates that the MSY for bottomfish in the main Hawaiian Islands is approximately 627,000 pounds per year. The 1988 catch was reportedly 1.7 million pounds, more than 2.5 times the MSY. Moreover, much of the *opakapaka, onaga, ebu* and white *ulua* catch was composed of juveniles, and there is concern that overfishing may have had an impact on spawning stocks (WESTPAC 1989b). Unlike the fishery in the NWHI, bottomfish stocks in the main Hawaiian Islands are being exploited by both commercial and recreational fishermen. The close proximity of this fishery to the main population centers in the State, combined with the involvement of recreational fishermen, undermines the economic self-regulation characteristic of the commercial bottom fishery of the NWHI.

Several of Hawaii's pelagic resources are far more abundant and under-exploited than other fisheries. However, there are no credible estimates of the sustainable yields of pelagic species within Hawaii's waters. There are indications that, from a Pacific-wide perspective, blue and striped marlin have shown a general decline in number and size. There are also indications that swordfish, sailfish and shortbill spearfish stocks could sustain some increased effort. However, there are not sufficient data available to determine that any pelagic stocks are in decline.

Some commercial catch statistics are available for Hawaii. The longline fleet harvested an estimated 1.2 million pounds of marlin, other billfish, *mahimahi, ono,* swordfish, spearfish and sailfish in 1987. Longline catches of these species increased to almost 4 million pounds in 1989. Trolling and handline boats caught about 5.3 million pounds in 1987 and only about 3.4 million pounds in 1989 (WESTPAC 1990j; 1990f). However, data on changes in fishing effort over this time period are unavailable.

As indicated, Hawaii's swordfish fishery has experienced a tremendous increase in landings since 1988. In 1988, swordfish landings totaled 50,000 pounds. In 1989, an estimated 500,000 pounds of swordfish were harvested by 10 vessels. In the first half of 1990, about 40 boats were targeting swordfish, and landings were five times those reported in 1989. There is as yet no indication that this increase is having a negative impact on the stocks. However, there is considerable concern about continued expansion of this fishery in the absence of any management controls (WESTPAC 1990d; 1990e).

There are significantly fewer data available on tuna than other pelagic species because there has been no statutory or regulatory requirements for reporting catch aside from Hawaii State commercial fishing reports. Data available on skipjack *(aku)* catches from these reports indicate that in 1971, approximately 16 million pounds were harvested. In 1988, *aku* catches totaled only 4 million pounds. The decline in catch appears to be a result of economic and market factors, as well as the closing of the tuna cannery, rather than over-exploitation. Therefore, there may be scope for the expansion of the *aku* fishery. The same may be true for surface yellowfin stocks and for the distant albacore stocks fished by Hawaii-based vessels.

Statistics on commercial landings of tuna show an increase in the catch by Hawaii's longline fleet of from 2.7 million pounds in 1987, to almost 5.9 million pounds in 1989. The majority of this increase was in yellowfin and big-eye. The trolling and longline fleet tuna catch declined from an estimated 3.1 million pounds in 1987, to about 1.6 million pounds in 1989 (WESTPAC 1990j). Again, there are no data to indicate how fishing effort was distributed among the various fleets over this period, and it is not possible to determine that there is any relationship between increases in longline catches and decreases in catches by other fleets.

Some fishermen claim that catches of larger yellowfin and big-eye tuna as well as other sport fish have declined as a result of increased exploitation by longline boats. However, there has been no systematic study of catch rates for these species, and size reduction usually occurs as stocks are fished down to the maximum sustainable yield.

User Conflicts

User conflicts have plagued fisheries development and management in Hawaii just as they have in other parts of the world. In Hawaii, user conflicts include: conflicts between longline boats using near-surface gear and small trolling boats in nearshore areas and around FADS; perceived competition between commercial fishermen and sport fishermen for pelagic stocks; conflicts between fishermen using spears, hook and line, and nets to exploit reef and nearshore species; and conflicts between fishermen and other ocean recreation users including surfers, swimmers, divers and pleasure boaters.

The most volatile conflict among fishermen in recent years involved newly arrived longline fishermen unfamiliar with local fishing conditions and customs. The recent arrivals were accustomed to using near-surface set longlines. Use of this gear in nearshore areas and around FADs resulted in considerable unrest among operators of small trolling boats. No Federal or State law provides a mechanism to resolve such conflicts, but a gentleman's agreement was made with the newly arrived longline fishermen. Nevertheless, sports fishermen and participants in the traditional small boat commercial fishery feel that longline boats should be prohibited from fishing within 75 miles of shore and that the expanded longline fleet has resulted in a decline in catches.

Although much less publicized, there are conflicts among fishermen using spears, hooks and lines, and nets in nearshore areas. Such conflicts are due to the inherent incompatibility of the fishing gear used and the perception that certain types of gear contribute more to over-exploitation than other types. Similar conflicts exist between fishermen and other ocean recreation users, including surfers, swimmers, pleasure boaters and divers. Some of these conflicts result from the "consumptive" nature of fishing as opposed to the "non-consumptive" nature of snorkeling and scuba diving.

One final user-conflict issue is the potential negative impact of commercial and recreational fishing on protected and endangered species. There have been allegations of fishermen attacking monk seals in the NWHI. There is also some concern that monk seals may be caught on longline hooks and that marine mammals and sea birds may get tangled in discarded nets and other fishing gear.

Lack of Resources for Fisheries Development

The development of harbors in Hawaii has not kept pace with the growth of commercial shipping and fishing, nor the demand for commercial boat launching ramps and recreational boating slips. Moreover, commercial fishing boats are not the major focus of the State's harbor development efforts. While there are plans to expand harbor facilities in Honolulu and other parts of the State, it appears that this expansion will not meet the needs of Hawaii's commercial fishing fleet and seafood marketing businesses. Without additional pier and docking facilities for commercial fishing boats and provisions for shoreside marketing and processing facilities, opportunities for maximizing the value of Hawaii's fisheries resources will be severely hampered.

There are currently 2,600 recreational boats on waiting lists for small boat harbor slips in the State (see Harbors Technical Paper). At least some are part-time commercial or recreational fishing boats, and the lack of adequate infrastructure for them will inhibit the growth of both recreational fishing and part-time commercial fishing.

The growth of recreational and commercial fishing as well as other boating activity has resulted in a shortage of docking facilities as well as boat ramps, refueling docks and other boating infrastructure. While the demand for support services and dockside amenities continues to grow, the supply is diminishing, and boats must wait longer and longer to use facilities (see Harbors Technical Paper; DBED/Sea Grant Program 1990).

Financial support is inadequate to stimulate the enhancement of the State's commercial fishing industry to maximize the value to fisheries resources. Moreover, insufficient support to promote the marketing of Hawaii's commercial catch is resulting in less than optimal prices for more abundant stocks. An expansion of the demand for under-exploited species of fish could make commercial fishing more profitable and minimize the fluctuations in ex-vessel prices. Greater effort aimed at encouraging commercial fishermen to target under-exploited species and at discouraging increased harvests of over-exploited stocks could reduce threats to the sustainability of Hawaii's fisheries resources.

Native Hawaiian Rights

There is considerable archaeological, historical and ethnographic evidence that Native Hawaiian fishermen have been dependent on the fishery resources in Hawaii for several centuries (WESTPAC 1989b). There is also evidence that traditional management methods, including a system of area closures, were used effectively by Hawaiian people before European contact. While traditional management methods are no longer practiced and traditional fishing rights are not widely recognized, traditional Hawaiian rights of access may conflict with State and Federal regulations in the future.

The pattern of long and continuous use of certain fishery resources and the recognition of special rights for Native Americans under Federal law may give Hawaiians special rights of access to certain fisheries. These fisheries may include those that are restricted by the State and/or the Federal government and those in need of further regulation.

Conflicts between traditional Hawaiian access rights and State and Federal regulations have not posed serious problems in Hawaii to date. However, as the need for further regulation increases and if area closures become a more widespread management method, conflicts may occur.

Ineffective Management and Interagency Coordination

Lack of Enforcement of Existing Regulations

The decline in Hawaii's nearshore fisheries resources is attributed in part to the inadequacy of enforcement of existing fisheries regulations (DLNR/DAR 1988a; DLNR 1988b). Some members of the fishing community, as well as staff professionals involved in fisheries research and management, have indicated that Hawaii has more than enough fisheries regulations. Others have indicated that existing fisheries regulations, particularly those governing nearshore and inshore fisheries, are overly complicated and unenforceable. It appears that the lack of effective enforcement capacity is due in part to the tremendous amount of shoreline to patrol; the inability of DOCARE to recruit and maintain qualified staff; and assignment of wildlife enforcement and other responsibilities to DOCARE officers.

Neither the State nor Federal government have adequate resources to enforce regulations governing Hawaii's offshore fisheries resources. Again, a lack of personnel and infrastructure hamper DLNR's ability to adequately enforce existing regulations. NMFS and the Coast Guard are charged with the surveillance and enforcement of fisheries regulations within Hawaii's 200-nautical mile Exclusive Economic Zone. Declining financial and personnel resources available to the Coast Guard have resulted in cutbacks in air and surface enforcement missions. Moreover, the Coast Guard has been given increased responsibility for drug enforcement and hazardous materials and oil spills management (Waihee 1990). This has further taxed resources that are needed for fisheries surveillance and enforcement.

Inadequate Statistics for Fisheries Management

Neither the Federal nor the State government can reliably assess the status of fish stocks or the adequacy of existing regulations because of inadequate statistics on fisheries in Hawaii. There are no reporting requirements for recreational fishermen. The vast majority of recreational fishermen are exploiting inshore and nearshore resources, those that have suffered most from over-exploitation.

Assessing the status of offshore stocks in the main Hawaiian Islands also is hampered severely by the lack of reporting requirements for recreational fishermen. Moreover, many of the data that are provided by commercial fishermen, who are required to report their catch, are incomplete and catch-per-unit-of-effort calculations cannot be made. There is also reportedly gross "underreporting" of commercial catch data. State officials indicate that this may be more a function of delinquent or non-reporting rather than falsification of catch reports. Nevertheless, it is estimated that commercial catch reports account for only 10 percent to 90 percent of the actual commercial catch, depending on the fishery.

Until 1990, the Fisheries Conservation and Management Act (FCMA) did not give the State or Federal government authority to manage or regulate tuna. Yet, commercial fishermen who market their fish in Hawaii are required to report tuna catches. Neither WESTPAC nor the State can require catch reports from foreign fishermen or from boats marketing their catch outside the state. Since Congress has removed the tuna exclusion clause in FCMA, this problem may be resolved to some degree.

Lack of a Consolidated Regime and Consistent Goals

DOCARE has the responsibility for the enforcement of existing fisheries regulations. DOT's Harbors Division has responsibility for the enforcement of State boating regulations. Neither Department has adequate resources to fulfill its statutory enforcement responsibilities.

Part of DBED's mission is to attract investment in Hawaii's fishing industry. To that end, DBED is actively encouraging investment in fishing and related industries. DLNR is attempting to increase its effectiveness in fisheries management and in handling user conflicts in the fisheries sector. Greater coordination of the investment promotion efforts of DBED and the resource management efforts of DLNR will be needed if effective fisheries management is to be achieved.

Regional coordination between Federal and State fisheries management activities are facilitated through the Hawaii Fishery Coordinating Council and WESTPAC on which Hawaii is represented. Cooperation between WESTPAC, NMFS and DAR has increased significantly in recent years. However, increased cooperation among these three agencies and with other marine research organizations could result in an improvement in the compilation and analysis of fisheries statistics for the State and in more effective fisheries management.

Lack of Adequate Marine Safety Requirements

Serious injuries and deaths among fishermen from 147 accident cases involving fishing vessels from 1965 to 1985 in Hawaii resulted in costs exceeding $6 million (Bourke and Markrich 1990). The financial and human costs of such accidents have been recognized by the Federal government as a national problem. In 1988, Congress promulgated the U.S. Fishing Vessel Safety Act, which calls for stricter controls and improved safety on fishing vessels. The Coast Guard is proposing safety regulations for commercial fishing vessels. However, the unique nature of Hawaii's "commercial fleet" with its relatively large number of part-time commercial fishermen may require additional safety improvements.

RECOMMENDATIONS

Objective

Provide a foundation for developing an integrated State fisheries management system that ensures: 1) depleted and overexploited stocks will be restored to sustainable levels; 2) fisheries resources will be harvested at their optimum sustain-

able yield; and 3) user conflicts will be minimized. [The most important feature of "optimum sustainable yield" is that it must be set at a level to prevent overfishing.]

Policy A

Assess the status and population dynamics of fisheries stocks (on an ongoing basis) and develop effective management regimes for inshore, nearshore and offshore resources.

Implementing Actions:

DLNR should:

1. Develop a comprehensive plan for the assessment, monitoring and management of nearshore and inshore stocks building on the Main Hawaiian Islands Marine Resource Investigation.

   a. Accelerate the Main Hawaiian Islands Marine Resource Investigation focusing on clear management objectives.

   b. Develop a feasible method for gathering catch and effort data for inshore and nearshore fisheries.

   c. Develop an integrated management plan for the management of inshore and nearshore fisheries.

2. Work with the NMFS, WESTPAC and the commercial and recreational fishing communities to adequately monitor the status of offshore fisheries resources.

   a. Establish better coordination of State and Federal compilation and analysis of fisheries statistics.

   b. Develop a feasible method for gathering catch and effort data from recreational fishermen.

   c. Develop a more effective mechanism for gathering commercial catch, effort and sales statistics.

   d. Secure adequate resources to insure compliance with reporting requirements.

3. Establish a mechanism for evaluating and improving the compilation and analysis of fisheries statistics to improve fisheries management.

Policy B

Assess the social and economic costs and benefits of a range of commercial and recreational fisheries development options to support the design of effective management and development regimes.

Implementing Actions:

DLNR should:

1. Commission a study of commercial and recreation fisheries options to assess the social and economic costs and benefits of a range of development designs.

2. Use the findings of the study to make changes in the management plan and fisheries regulations based on the plan.

3. Commission updates of the socio-economic analysis as needed.

Policy C

Coordinate private-sector, State and Federal fisheries development and management efforts.

Implementing Actions:

DLNR, in cooperation with DBED, NMFS and WESTPAC, should:

1. Evaluate the role and potential effectiveness of the Hawaii Fisheries Coordinating Council in light of changes in fisheries management structure based on the Ocean Resources Management Plan.

2. Make such changes in the mandate of the Coordinating Council as may be required to fit into the new management structure and to improve coordination of Federal, State, County and private-sector fisheries development and management.

3. In coordination with the State, develop recommendations for enhancing the role of WESTPAC in the management of Hawaii's fisheries.

Policy D

Ensure that native Hawaiian fishermen receive all the rights to which they are entitled.

Implementing Actions:

DLNR should:

1. Evaluate the findings of the WESTPAC study "Native Hawaiian Fishing Rights."

2. Review existing Federal and State regulations that may pertain.

3. If the above evaluation and review indicates Hawaiian fishermen should receive preferential rights in the U.S. EEZ surrounding the State, recommend changes to existing State and Federal regulations to afford such rights.

Policy E

Maximize the use of scientific and management resources.

Implementing Actions:

DLNR, with assistance from UH and other research and educational institutions, should:

1. Develop (or enhance an existing) roster of fisheries research and management resources.

2. Establish a research coordinating committee for DLNR or the participatory management body described above.

3. Develop a long-range fisheries research plan consistent with the integrated fisheries management plan and meet the needs of the fisheries management body to ensure more effective fisheries management.

4. Develop projects similar to the Main Hawaiian Islands Marine Resource Investigation to meet ongoing fisheries management needs.

Policy F

Ensure reasonable access to fisheries resources for subsistence, recreational and commercial fishermen as well as other recreational users (e.g., divers) and aquarium fish collectors.

Implementing Actions:

DLNR should:

1. Through a participatory planning effort involving representatives of various segments of the fishing community and other marine users, devise management regimes that provide reasonable access to fisheries resources.

2. Using such methods, conduct periodic reviews of fisheries management and regulatory mechanisms to ensure such mechanisms continue to meet Hawaii's fisheries management needs.

Policy G

Minimize and resolve user conflicts among fishermen and between fishermen and other ocean resource users.

Implementing Actions:

DLNR should:

1. Evaluate fisheries conflict resolution methods employed by other states and identify methods that might be adapted for use in Hawaii.

2. Develop a conflict resolution mechanism to resolve user conflicts among fishermen and between fishermen and other ocean users that enhances communication.

   a. Formally establish such a mechanism through legislation or regulation.

   b. Develop a screening system for use of such a mechanism.

   c. Limit the time allowed for mediation or negotiation.

   d. Ensure that the agreements resulting from negotiations or mediation are binding.

   e. Develop a public awareness program to encourage the use of such a mechanism.

3. Review existing fisheries regulations and set up a system to review proposed regulations to ensure that user conflicts are minimized.

4. Evaluate the role and potential impacts of commercial fishing vessels, and regulate their influx if necessary.

Policy H

Support trade and investment promotion, seafood marketing support, and the promotion of sports fishing and fisheries-related tourism.

Implementing Actions:

DBED, in cooperation with DLNR, should:

1. Work with the commercial fishing community and seafood marketers to review existing trade and investment promotion activities and identify new opportunities for trade and investment promotion.

2. Develop a long-range plan for trade and investment promotion that encourages the development of fisheries resources.

3. Enhance existing trade and investment promotion efforts to encourage and expand commercial development of under-exploited species through commercial fishing, charter boat fishing and marine tourism.

Policy I

Restore depleted stocks and enhance existing stocks by developing an effective management regime.

Implementing Actions:

DLNR should:

1. Develop a long-range plan for stock restoration and enhancement including consideration of the construction of artificial reefs and stocking of nearshore areas with cultured species.

2. Work with segments of the fishing community to develop a stock restoration and enhancement program.

3. Reevaluate existing fishing regulations with the goal of developing an effective and enforceable management system.

4. Develop an acceptable and enforceable system of closures to allow nearshore fisheries stocks to recover from over-exploitation.

5. Develop a public awareness campaign on fisheries regulations and the management of Hawaii's fisheries.

6. Develop a program for stock enhancement based on the plan.

7. Develop a public education program to encourage exploitation of under-utilized species and improved management of over-exploited species.

Policy J

Provide appropriate infrastructure for recreational and commercial fisheries development. [See Harbors section.]

Implementing Actions:

DOT, DLNR, and DBED together should:

1. Review the comprehensive fisheries management plan [see Policy A, Action 1] and existing harbor and marina development plans to ensure the needs of various segments of the fishing community are adequately met

while the long-range fisheries development objectives can be achieved.

2. Develop a fisheries infrastructure development and finance plan that incorporates existing plans and integrates the development of commercial harbors, marinas, boat ramps, artificial reefs, fish aggregating devices (FADS) and other fisheries infrastructure.

3. Develop proposals for State, Federal and private-sector funding to implement the plan.

4. Establish a mechanism for ensuring coordination of infrastructure management under existing agencies or designate a single lead management agency to assume that function .

Policy K

Evaluate marine safety needs of commercial and recreational fishermen and facilitate developing programs to reduce accidents.

Implementing Actions:

DOT and DLNR, in cooperation with the U.S. Coast Guard, should:

1. Develop a voluntary marine safety training program for commercial and recreational fishermen.

2. Evaluate licensing and other procedures to improve marine safety on commercial and recreational fishing boats.

3. Develop public awareness programs to encourage participation in training programs and proper maintenance of equipment.

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MARINE ECOSYSTEM PROTECTION

THE RESOURCE

Hawaii's marine and coastal environments are the backbone of its economy and integral to its history and culture. Historically, these environments defined communities and provided many of the resources upon which the traditional economy depended. More recently, the tourism industry, which now contributes significantly to the State's economy, has become dependent upon quality marine and coastal environments. The resources contained within these natural environments are diverse and numerous: marine life, including marine mammals, sea turtles, birds and fishes; endemic and exotic plant species; critical and productive habitats such as coral reefs, estuaries, wetlands, offshore islets and rocks, and anchialine pools; scenic land and seascapes, including beaches, rugged shorelines and underwater lava formations; and deep seabed minerals.

A host of people, organizations and ocean industries utilize or are dependent on Hawaii's coastal and marine resources. These users include: aquaculturists, fishermen, education and research institutions, shipping and related industries, tourists and outdoor enthusiasts, tourism industry, and ocean technology research and development programs.

On one hand, these ocean industries benefit Hawaii's economy and enhance people's understanding of ocean and

coastal processes. On the other hand, these user groups and an expanding human population can negatively impact these natural environments upon which they depend. Growth and tourism-related development onshore can result in: loss of critical marine habitats; siltation from urban and agricultural runoff; and decreasing nearshore water quality from inadequate waste disposal capabilities. Fishing, aquarium and souvenir collection can deplete unique or important marine resources. The maritime industry can contribute to reduced water quality through operational and accidental discharges of oil and fuel. Boat anchoring, seabed mining operations and bottom trawling can disturb coral reefs and other underwater formations.

Clearly, the issue of protecting marine and coastal environments against degradation merits attention. Hawaii State policy incorporates a conservation ethic in resource management, which includes both elements of environmental protection and resource use (Chapter 228-1, HRS). However, due to the opportunities presented for economic development, resource use, in many cases, has been emphasized more than environmental protection. Enhanced ecosystem protection requires a shift in this balance.

The existing system of marine and coastal protected areas, and the existence of ordinances regulating types and levels of resource use within the State provide some marine and coastal environments with varying degrees of protection. The levels of protection afforded these environments range, in theory, from strict preservation to promotion of multiple uses. In practice, however, there is a tendency towards leniency in use restrictions. It seems apparent that there is room for improvement with regard to ecosystem protection in Hawaii. Furthermore, given the large percentage of coastal lands owned by the State, Hawaii has ample opportunity to increase resource protection to benefit current and future users.

Resource Value

While marine and coastal resources are essential to the success of Hawaii's ocean industries and overall economy, they are also valuable in ways not easily quantifiable and, until recently, ignored. Engendering support for better and more comprehensive protection of the marine ecosystem requires a broadening of perceptions regarding resource value.

Economic Value

Hawaii's economy is intricately linked to its surrounding ocean. Economic diversification is a constant theme and one of the major forces motivating Hawaii's interest in the ocean (MacDonald and Deese 1989). The tourism industry, the State's economic mainstay, is almost entirely dependent on excellent water quality and a healthy environment. The commercial fishing industry, which landed approximately 20 million pounds of locally-caught fish valued at $42 million in 1988, depends on the maintenance of abundant and healthy fish stocks (see Fisheries Technical Paper). Marine pollution and habitat destruction reduce these fish stocks.

Scientific and Educational Value

Marine ecosystems provide important sites for scientific study and education. Preserves that are relatively unmodified or "pristine" can generate important geologic, oceanographic and ecological data. The Northwestern Hawaiian Islands, for example, provide a unique window on species evolution because of their geographic isolation and are preserved as the Hawaiian Islands National Wildlife Refuge. Marine protected areas, which protect habitats, nesting, nursery and feeding grounds of threatened and endangered species, provide unique scientific and educational opportunities. Ecosystems in which human activities can be controlled also provide baseline data from which to evaluate the impacts of such activities.

The ocean research and development industry also values a thriving marine environment. Research and development projects can translate into technological innovations that may generate new economic opportunities in the State. In 1989, the economic value of ocean research and development was $62 million. The projected value for 1992 ranges between $87 and $147 million (MacDonald and LaBarge 1990).

In addition, marine ecosystems function as learning centers for public education programs. Environmental organizations and schools use field trips to coastal lands and nearshore waters to cultivate heightened environmental awareness. Designating underwater parks and trail systems can make marine resources more accessible to the public for study. Educating and exposing people to resource values and the environmental effects of human impacts can reduce the need for enforcement by helping to alter environmentally damaging practices (See Ocean Research and Education Technical Paper).

Cultural and Historical Value

Resources also are valued for their role in ancient culture. Areas used by ancient Hawaiians — including fish ponds, traps, anchialine pools and whole fishing villages — provide valuable cultural resources to both residents and visitors. Fish ponds, for example, were constructed by the Hawaiians from embayments and naturally forming anchialine pools. Anchialine pools also were modified to facilitate the catching of natural stocks of *opae'ula* (red shrimp) to be used as fish bait. *Pipiwai* snails and *hihiwai* snails (nerities) were gathered from anchialine pools. These food and water resources helped sustain the ancient Hawaiian communities that colonized and settled around the pools. Proper interpretation of these areas is important to cultivate in today's society the same sense of *malama aina* or "protecting the land" that existed in early Hawaiian culture. As with other important historical and cultural resources, these pools need specific protection from development pressures.

Recreational and Aesthetic Value

People are drawn to natural environments for recreation because of the natural amenities such environments provide. Which kind of environment a person chooses to visit depends in part on the nature of the recreation experience the person

seeks. A person pursuing an isolated wilderness experience values the relative absence of urban concentrations, freedom from evidence of human alteration, the absence of pollution, the presence of appealing vistas, and relative peace and quiet. On the other hand, a person wishing to sunbathe on a popular beach considers the beach's proximity to home, opportunities for particular recreational activities, safety, cleanliness and facilities. The marine and coastal environments provide opportunities for this range of recreational experiences (See Ocean Recreation Technical Paper).

Resources also have "existence" value, which is largely unquantifiable. This describes the value that people place on natural resources and environments simply because they exist. Many people are content to know that certain species (e.g., Hawaiian monk seal), ecosystems (e.g., coral reefs) and natural features (e.g., underwater lava tubes and arches) exist, even if they will not personally observe them.

Ecological Value

Every coastal and marine resource contains an ecological value because of its crucial role in maintaining the overall balance of ecological processes. Marine ecosystems depend heavily on properly functioning ecological processes. Energy and nutrient flows are critical to species survival. Estuaries such as Pearl Harbor and Kaneohe Bay, for example, function as nutrient and sediment traps. They also serve as nurseries for a variety of fish and invertebrates, as well as habitats for endangered species. Furthermore, they help reduce the effects of erosion from storm-induced wave surges and flooding. The continued existence of any species depends directly on the preservation of its habitat. Although the value of this preservation may not be quantifiable or even identifiable, a specie's demise or extinction because of habitat loss eventually affects the overall balance of natural systems.

RESOURCE MANAGEMENT

It is Hawaii's policy to preserve, protect and, where possible, restore the natural resources of the State's coastal zone (Chapter 176, Hawaii Revised Statutes [HRS]). An array of management systems exists in Hawaii at the Federal, State and County levels, and within the private sector, designed to preserve coastal water quality and protect fauna, flora and their habitats from pollution, human and development pressures. Some management systems aim to broadly protect Hawaii's coastal and marine environments; others target specific ecosystems, habitats and species.

Protection of Overall Marine and Coastal Environments

Federal Authority

U.S. Army Corps of Engineers Permit Process

Any construction in coastal, tidal waters below the mean high water mark requires a permit from the U.S. Army Corps of Engineers (COE) under Section 10, Rivers and Harbors Act. Any discharge of dredge or fill material into waters of the United States, which includes wetlands, anchialine pools, rivers, streams and coastal waters, requires a permit from the COE under Section 404, Clean Water Act. Permit applicants are required to obtain State of Hawaii Coastal Zone Management Federal Consistency Determinations and Section 401, Clean Water Act, Water Quality Certifications, prior to being issued a permit by the COE. The decision to authorize a proposed action is based on public interest evaluation and evaluations in compliance with the National Environmental Policy Act (NEPA), Endangered Species Act and National Historic Preservation Act.

State Authority

Water Quality Standards

The Department of Health (DOH) has established water quality standards (Chapter 11, Hawaii Administrative Rules, [HAR]) based on Federal Environmental Protection Agency (EPA) water quality standards established under the Clean Water Act. DOH water quality standards classify all State waters as either marine or inland waters. These waters are further classified by use for the purpose of applying standards.

Marine waters are divided into Class AA and Class A waters. Marine bottom ecosystems are divided into Class I and Class II. There are basic water quality criteria applicable to all waters that address floating debris, thermal pollution, turbidity, and nearly 100 toxic substances. These standards also describe certain uses and specific criteria applicable to inland and marine waters.

In addition, these water quality regulations include some level of natural resource protection, demonstrated by the objective for Class AA waters, which specifies that "...to the extent practicable, the wilderness character of these areas shall be protected" [Chapter 11-54-03(c)(1), HAR]. These waters include "pristine" areas along Hawaii's coastline, and "...all embayments in preserves, reserves, sanctuaries and refuges" [Chapter 11-54-06(a)(2), HAR]. No effluent discharge is allowed in these waters in depths less than 10 fathoms. Controlled allowable uses include "oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation and aesthetic enjoyment" [Chapter 11-54-03(c)(1), HAR]. Class A waters are to be protected for recreational purposes and aesthetic enjoyment. Activities are permitted provided they are compatible with protection and propagation of fish, shellfish and wildlife [Chapter 11-54-03(e)(2), HAR]. There are specific standards for each classification of waters.

Natural resource protection is also evident in the classification of bottom environments given in DOH water quality regulations. Class I bottom environments are protected so that they "remain as nearly as possible in their natural pristine state with an absolute minimum of pollution from any human-induced source. Allowable uses of marine bottom ecosystems in this class are passive human uses without intervention or alteration, allowing the perpetuation and preservation of the marine bottom in a most natural state, such as for non-con-

sumptive scientific research, non-consumptive education, aesthetic enjoyment, passive activities and preservation" [Chapter 11-54-03(d)(1), HAR]. The management objective of Class II bottom environments is that "their use for protection including propagation of fish, shellfish, and wildlife, and for recreational purposes not be limited in any way." Any action that may permanently modify the bottom environment is allowed only with approval of the DOH director, after consideration of environmental impact and public interest [Chapter 11-54-04(d)(2), HAR]. There are specific regulations for each classification of bottom environments.

Finally, State water quality standards contain specific rules regarding discharges in and water quality parameters for anchialine pools and wetlands.

Hawaii Environmental Impact Statement (EIS) Law: The Hawaii Environmental Impact Statement law (Chapter 343, HRS) grew out of the need to identify and mitigate potential environmental impacts from activities undertaken or approved by State and County governments. This law is Hawaii's State environmental policy act, modeled after the National Environmental Policy Act (NEPA). The EIS Law requires that Environmental Assessments (EAs) be prepared for actions that propose any of a list of uses or amendments to certain plans (Chapter 343-5, HRS). If a "negative declaration" (i.e., there will be no impact) is made, then no further environmental impact analysis is required.

If the State agency preparing the EA determines that a proposed activity may significantly affect the environment, an Environmental Impact Statement (EIS) is required. When the EIS is completed, it is made available for public comment. Depending on whether the activity anticipates use of State or County resources, the Governor or the mayor has the authority to accept the EIS (Callies 1984). Developments proposed for State conservation districts and shoreline setback coastal areas are two of several uses that require an assessment (Chapter 343-5, HRS).

Hawaii Coastal Zone Management (CZM) Program: Under Hawaii's CZM Law (Chapter 205A, HRS), all State and County actions within the CZM area must comply with the CZM objectives and policies. In addition, since the State's CZM Program has been officially approved by the Federal government, the national CZM Act (CZMA [P.L. No. 92-583]) requires all Federal activities undertaken in or affecting Hawaii's coastal zone to be consistent with Hawaii's CZM Program. Where national defense or other overriding national interests are concerned, Federal activities must at least be consistent to the "maximum extent practicable." As the lead agency for CZM in Hawaii, the Office of State Planning (OSP) is responsible for reviewing and deciding the consistency of Federal activities with the State's CZM Program. These include direct Federal activities, outer continental shelf activities, Federal funding, and Federal permits and licenses.

The CZM Program also is responsible for reviewing the actions of State and County agencies for compliance with Hawaii's CZM Law and State programs in the CZM area for consistency with the CZM Program.

Within this same State statute, the designation of Special Management Areas (SMAs) provides a method for special controls over coastal development. The Legislature found that these controls were "...necessary to avoid permanent losses of valuable resources and the foreclosure of management options, and to ensure that adequate access, by dedication or other means, to public owned or used beaches, recreational areas and natural reserves is provided" (Chapter 205A-21, HRS).

Soil Erosion Control Permit Process: Soil erosion is a major nonpoint source pollution problem. To control this, agricultural operations are to use "best management practices" as described in Hawaii's *Nonpoint Source Water Pollution Management Plan* (DOH 1989). Construction operations must obtain a grading permit from the County. This permit system is being evaluated for its effectiveness in controlling soil erosion by the State's Nonpoint Source Pollution Program (See Waste Management Technical Paper).

Conservation District Permit Process: Conservation District Use Applications (CDUAs) must be filed by those proposing to engage in any activities not listed in the Hawaii Administrative Rules for Conservation Areas (Title 13, Chapter 2, HAR). Activities requiring CDUA permits include construction of park infrastructure, commercial operations and installation of moorings. A Department of Transportation (DOT) use permit also is required for installation of moorings. DLNR Conservation and Environmental Affairs Division oversees the CDUA process.

County Authority

Special Management Area Permit Process: Within each County, Special Management Areas (SMAs) are designated for areas requiring special management attention. SMAs extend inland a minimum of 100 yards and, in undeveloped areas, often are extended further inland. Specific management authority rests with the City Council on Oahu and the planning commissions on the Neighbor Islands. The Counties define the types of activities that constitute development, and establish SMA boundaries. SMA guidelines are outlined in Chapter 205A, HRS (Hawaii's CZM Law), and include the following requirements: adequate public access to shoreline areas; adequate public recreation areas and wildlife preserves; waste management; water resources management; no substantial adverse environmental or ecological impacts; and consistency with State and County planning and zoning.

The Counties are to "seek to minimize, where reasonable" dredging, filling, or other alteration of bays, estuaries, salt marshes, river mouths, sloughs and lagoons; reduction in size of beaches or other public recreation areas; developments that would restrict access to coastal areas; developments that would "substantially interfere with or detract from the line of sight toward the sea from the State highway nearest the coast"; and, "any development which would adversely affect water quality, existing areas of open water free of visible structures, existing and potential fisheries and fishing grounds, wildlife habitats, or

potential or existing agricultural uses of land" [Chapter 205A-26(3)(A)-(E), HRS].

Special Management Area use permits are required for the coastal developments listed above. DOT has an exemption from this requirement for the construction of public harbors. Permits are issued by Counties after environmental analyses and public hearings are conducted. Any rules and regulations adopted by the Counties for the SMA process must be consistent with Hawaii's CZM Law. Action on SMA use permits is final unless otherwise mandated by court order (Chapter 205A-29, HRS). There are also provisions for emergency and minor permits (Chapter 205A-30, HRS).

Protection of Ecosystems and Habitats

Certain marine and coastal areas are protected under Federal or State law. The federal government has institutional and regulatory mechanisms with which to confer a degree of protection on unique or significant ecosystems and habitats. It is the State's policy to establish and maintain natural area preserves, wildlife preserves, marine preserves, and unique ecological preserves (Chapter 344-4, HRS). Many of these areas are considered Areas of Particular Concern (APCs) under Hawaii's CZM Law and require special management attention.

Federal Protected Areas

National Marine Sanctuaries (NMSs): The NMS Program is administered by the National Oceanic and Atmospheric Administration (NOAA), Marine and Estuarine Management Division. The primary purpose of the program is resource protection. It enables the Federal government to manage designated marine environments as ecosystems. The program's mission also allows for the facilitation of multiple uses within designated NMSs. In the early 1980s, the national government proposed to create an NMS for the waters off Maui in order to protect humpback whale breeding grounds. However, the proposal died because it did not garner adequate State support.

National Wildlife Refuges (NWRs): In designating National Wildlife Refuges, the U.S. Fish and Wildlife Service (FWS) seeks to protect bird, and to a lesser extent, marine mammal habitats. The Hawaiian Islands NWR was created in 1909 for the protection of numerous sea and shore birds. It is managed by FWS with strict controls on human interactions with the wildlife. Even scientific and educational visits are extremely limited and closely supervised. The islands and offshore waters provide habitats for over five million seabirds of 18 different species, including albatross, boobies, frigate birds, petrels, shearwaters, storm-petrels, terns and tropic birds.

National Estuarine Research Reserves: Waimanu Valley on Hawaii is designated as a National Estuarine Research Reserve, under NOAA, Office of Coastal Resources Management. While it is a Federal reserve, the protected area itself is managed by the State. The goal of such designations is long-term habitat protection for research and educational purposes.

Coastal National Parks: In some marine areas adjacent to coastal national parks, the National Park Service (NPS) seeks to regulate activities. Under the Hawaii National Parks Act, NPS can extend its jurisdiction over adjacent marine areas and develop rules regulating fishing and taking of other marine life (Sections 1,4). However, since these marine areas are State waters, their management requires a joint Federal-State plan. Efforts are currently underway to develop such a Federal-State management plan for waters off Kaloko-Honokohau National Historic Park in Kona.

Other Federal Marine Protected Areas: Designating critical habitat areas for threatened and endangered species is another mechanism for providing recognition and protection of essential habitats. In addition, development proposals for projects in or adjacent to anchialine pools, fishponds and wetlands are reviewed by COE, FWS and EPA. Though President George Bush has announced his intention to adopt a policy of "no net loss of wetlands," no implementing rules have been adopted. Pools and wetlands are protected under the Clean Water Act.

State Protected Areas

Marine Life Conservation Districts (MLCDs): The State established MLCDs to protect unique areas of the marine environment (Chapter 190, HRS). The State Department of Land and Natural Resources (DLNR), Division of Aquatic Resources, is responsible for establishing, managing and regulating uses in these MLCDs (Chapter 190-15, HRS). Within each MLCD, the DLNR develops administrative rules and monitors the resources annually. These rules may prohibit the taking of marine life except by permit for scientific, educational or other purposes, under conditions that cause minimal environmental impacts (Chapter 190-4, HRS). Rules generally prohibit taking of marine life in MLCDs, emphasizing preservation of the areas' marine flora and fauna, and their habitats (Chapters 13-28 to 13-35, HAR). MLCDs have been designated at Hanauma Bay, Oahu; Kealakekua Bay, Hawaii; Manele-Hulopoe, Lanai; Molokini Shoal, Maui; Honolua-Mokuleia, Maui; Lapakahi, Hawaii; Pupukea, Oahu; Wailea Bay, Hawaii, and Waikiki, Oahu.

Fishery Management Areas (FMAs): State regulations restrict fishing activities within FMAs (Chapters 13-47 to 13-54, HAR). DLNR's Division of Aquatic Resources is responsible for establishing and managing FMAs, and regulating activities (Chapter 187-2, HRS). These FMAs include the Northwestern Hawaiian Islands; Waikiki-Diamond Head Shoreline, Oahu; Hanamaulu Bay and Ahukini Recreational Pier, Kauai; Waimea Bay and Waimea Recreational Pier, Kauai; Kahului Harbor, Maui; Kailua Bay, Hawaii; Manele Harbor, Lanai; Puako Bay and Puako Reef, Hawaii; and Kawaihae Harbor, Hawaii.

Natural Area Reserves System (NARS): The goal of NARS is to protect unique natural areas from loss due to population growth and technological advances (Chapter 195, HRS). NARS is administered by DLNR's, Natural Area Reserve System Commission (Chapter 195-6, HRS). The Natural Area Reserve System Commission is responsible for recommending criteria, evaluating potential sites and recommending specific areas for inclu-

sion in the NARS (Chapter 195:3-7, HRS). There is one NAR, located at Ahihi-Kinau, Maui, that includes a marine component; Kaena Point on Oahu is a coastal NAR but does not extend into the water. Rules have been adopted governing activities in these protected areas, including prohibitions on operation of motorized vehicles.

Underwater Parks: Two MLCDs, Hanauma Bay and Kealakekua Bay, also are designated State Underwater Parks. DLNR, State Parks, Outdoor Recreation and Historic Sites Division, has the authority to manage the parks (Chapter 184, HRS). However, they do not currently do so, relying instead upon DLNR, Division of Aquatic Resources, to manage these areas as MLCDs.

Conservation Land Use District Protective Subzone: Within the State's Conservation Land Use Districts, Protective Subzones can be created to include shorelines and parts of the adjacent ocean. Protective Subzones help preserve natural ecosystems necessary to native fish species, particularly endangered species. All of the Northwestern Hawaiian Islands, excluding Midway, are a Conservation Land Use District Protective Subzone. Hunting and fishing may be allowed to control populations (Chapter 13-2, HAR).

Other State Marine Protected Areas: There are other State-designated areas that restrict, to varying degrees, consumptive uses of the marine environment. A Marine Laboratory Refuge is located at Coconut Island in Kaneohe Bay on Oahu. Several boat harbors and canals have restrictions on fishing, including Honolulu Harbor, Ala Wai Canal, Kapalama Canal, Heeia Kea Wharf, Pakai Bay and Waialua Bay, Oahu; and Hilo Harbor, Hawaii. Fishing and some other activities are regulated within such areas as: Alakai Wilderness Preserve, Kauai; Paiko Lagoon Wildlife Sanctuary, Oahu; and many Hawaii State Seabird Sanctuaries on various islands and islets throughout the State. State seabird sanctuaries are managed by DLNR, Forestry and Wildlife Division.

Ocean Recreation Management Areas (ORMAs): Some ORMAs are designated to prohibit operation of certain types of watercraft during the winter season when humpback whales are present. Other areas are closed for protection of sea turtle habitats. These closures reduce the potential for harassment of these species. ORMAs are managed by DOT, Harbors Division.

State Enforcement Responsibility

Enforcement within MLCDs, FMAs, NARs and Underwater Parks is conducted by DLNR, Division of Conservation and Resources Enforcement (DOCARE), in cooperation with other Federal, State and County agencies. DOCARE has a limited number of enforcement personnel on each island — 21 on Oahu, 15 on Maui, 11 on Kauai, and 15 on Hawaii — covering both terrestrial and marine-protected areas. None are specifically assigned to marine-protected areas.

Within most marine-protected areas, DOT, Boating Branch, has jurisdiction over vessels (or buoys) on the water's surface (Chapter 261-1, HRS). DOT, Office of Safety and Law Enforcement, is responsible for enforcing boating laws (Chapter 267, HRS). However, within MLCDs, DLNR has the authority to regulate moorings (Chapter 190, HRS).

DOH is responsible for monitoring water quality in nearshore waters, including marine-protected areas, and enforcing compliance with EPA and State water quality standards (Chapter 342-31, HRS).

Private Protected Areas

Private organizations are beginning to increase their involvement in the purchase and/or management of marine and coastal areas. The Nature Conservancy, for example, owns and manages two preserves with significant coastal resources: Moomomi and Pelekunu Preserves on Molokai. The Conservancy's mission in Hawaii is to protect the full range of indigenous species and ecosystems.

Special Cases

Anchialine pools are protected as unique ecosystems only in the Cape Kinau Natural Area Reserve, Volcanoes National Park and Kaloko-Honokohau National Historical Park. The remaining anchialine pools are located mostly on private lands and are subject to protection only to the extent that Federal, State and County permits are applicable to private development of those lands and to the extent provided by permit conditions. For the most part, anchialine pools are located within County Special Management Areas. DOH water quality regulations state that all anchialine pools shall be maintained in their natural state with no discharges allowed (Chapter 11-54-05.2, HAR). The pools also are protected by COE under the CWA. COE has a memorandum of agreement with EPA and FWS to attempt to protect the pools to the extent reasonable within EPA guidelines. Anchialine pools are not considered wetlands (except perhaps some parts of the shoreline in the pools).

The public is responsible for the introduction of exotic fish and trash into anchialine pools. Private development offers partial protection in that private developers are not filling anchialine pools in order to avoid Federal or State regulatory intervention in their projects. Developers are willing to provide some protection only to the extent that their projects can proceed in consideration of costs for providing the protection.

Some wetlands are protected and managed to the extent that they are included as preservation or conservation areas in State and County land-use plans and to the extent that they are included in existing Federal and State waterbird wildlife refuges. Other wetlands are protected to the extent that they require permits from COE.

Several problems are associated with wetland protection in Hawaii. First, the emphasis on wetland protection is relatively new and many wetland areas are zoned for development in State and County land-use plans. Second, there is a lack of a common Federal and State definition for wetlands, lack of regulatory jurisdictional wetland maps, and lack of State or County statutes, strategies and initiatives for wetland protection. DOH has a wetland definition in regards to discharges into State waters, and the State Comprehensive Outdoor Recreation

Plan (SCORP) has included a wetland strategy. The City and County of Honolulu is working on wetland legislation and the State is attempting to develop a resource plan that includes wetlands.

Oil and chemical spill response in Hawaii waters is conducted by the DOT, DOH and U.S. Coast Guard to minimize the damage caused to coastal and marine environments in the event of a spill or discharge (See Waste Management Technical Paper).

Protection of Marine and Coastal Species

Federal Authority

Several marine species are protected under the Federal Endangered Species and the Marine Mammal Protection Acts. Hawaiian monk seals, sea turtles and humpback whales are considered protected marine species. Hawaiian monk seals are found primarily in the Northwestern Hawaiian Islands. Occasionally, they are found on the main Hawaiian Islands. Their population has halved since the 1950s. Estimates made in 1987 placed their population between 1,500 and 1,700 individuals. Human harassment contributed to their earlier demise, but the present population appears stable.

For the most part, these species are managed by the National Marine Fisheries Service (NMFS). FWS shares with NMFS jurisdiction for listed sea turtles, and responsibility for management and protection of Hawaiian monk seals because most of the monk seal habitat is within the FWS Hawaiian Islands National Wildlife Refuge in the Northwestern Hawaiian Islands. There are strict regulations on human interactions with these animals.

Two endangered species of sea turtles, the leatherback and hawksbill, and a threatened species, the green sea turtle, inhabit coastal waters of Hawaii. Two other turtle species, the olive Ridley and loggerhead, are rare visitors to Hawaii's waters. The green sea turtle is the most common species. Although the population was declining, it now appears stable. Over 90 percent of its mating activities occurs at French Frigate Shoals. In the main Hawaiian Islands, its nesting beaches are limited to Mo'omomi on Molokai and other unnamed sites on Oahu and Kauai. Hawksbill nesting beaches are located at Orr's Beach, Punalu'u, Kamehame, and formerly at Kalapana on Hawaii, and at Halawa on Molokai.

The humpback whale, the State's designated marine mammal, is one of the most severely depleted of all whale species. Rough estimates place Hawaii's population at approximately 1,200-1,500 individuals. From December through May, humpbacks migrate to Hawaii's waters to mate and give birth. Each summer, they return to their feeding grounds along the Alaskan Peninsula or elsewhere in the northern regions of the Pacific.

State Authority

It is the State's policy to protect endangered species of indigenous plants and animals and introduce new plants and animals only after ensuring that such introductions will pose negligible ecological hazard (Chapter 344-4, HRS). DLNR accords those species designated "endangered" or "threatened" under the Federal Endangered Species Act the same status under State law. DLNR also may designate other species by administrative rule (Chapter 195D-4, HRS). A list of endangered and threatened species appears in Chapter 124, HAR. DOCARE enforces State regulations concerning protected species, in cooperation with other Federal, State and County agencies.

MANAGEMENT ISSUES

At a time when coastal development and marine resource use are occurring at a rapid rate, the management and protection of significant marine and coastal areas and resources have not kept pace. A number of management issues and sub-issues must be addressed before the marine and coastal resources of Hawaii will realize their full economic, education, scientific, recreational, cultural and ecological values.

Continued Species and Habitat Loss and Damage

Increasing coastal development and marine activities already have impacted many natural environments. Before the taking of coral was made illegal, this activity had a significant and cumulatively adverse effect on Hawaii's reefs. Still, many tourists are not aware of the restrictions on this kind of souvenir collection. Coral reefs also have been affected by freshwater runoff and sedimentation associated with urbanization. Decreased salinity kills coral polyps and other marine life; sedimentation smothers corals; turbidity from silt-laden runoff reduces light availability vital to the reefs. Boat anchors also damage coral.

In the past, anchialine pools and wetlands, now recognized as unique and irreplaceable natural resources, have been filled or drained for coastal developments. In other cases, the ecology of some anchialine pools and fishponds has been dramatically altered by the introduction of alien species of fish, which compete with the indigenous species for dominance over the habitat. Hawaii's estuaries are also especially sensitive to environmental insults. Contamination from point and nonpoint sources may exceed the assimilative capacity of the estuaries, threatening the integrity of their resources. As habitats, feeding and breeding grounds degrade or are lost, populations, including those of threatened and endangered species, decrease.

Coastal vegetation has been destroyed by the development of shoreline structures and the increasing use of off-road vehicles, exacerbating coastal erosion problems in many areas. Shoreline construction also may disturb nearshore resident species sensitive to siltation and noise, and disrupt critical behavioral patterns.

Human-induced pressures have contributed to a significant decline in coastal fishery resources during the 20th Century (NMFS 1987), through overfishing and habitat degradation. Oil and hazardous chemicals affect both individual organisms and whole ecosystem assemblages through asphyxiation and poisoning. These losses have both ecological and economic reper-

cussions. Plastic debris — in the form of nets, lines, food packaging, and other items — found in the oceans and along the coasts increasingly threatens marine life. Smaller pieces of plastic are ingested causing death through blocked passages, ulcerations, toxic accumulation and starvation. Entanglement from discarded or lost fishing gear, such as drift nets, causes death through drowning.

Inadequate Management of Some Marine and Coastal Resources and Areas

Lack of Integrated Marine and Coastal Management Plans

Currently, management of marine and coastal areas is done on a piecemeal basis. While many individual areas are protected to varying degrees, there is no comprehensive management plan for Hawaii's coastline and nearshore waters. Individual resources and areas, which may be linked ecologically, often are managed without coordination by different agencies. As human, technological and development pressures continue to increase, protection of resources and open space will necessitate their comprehensive management in a coordinated manner by Federal, State and County authorities.

Furthermore, there is a lack of integration in present planning regarding terrestrial and marine resource management. It is important to recognize the connection between the wet and dry sides of the coastal zone. In fact, in Hawaii, the inland boundary of the coastal zone stretches, with the exception of forest reserves, across all land masses. Obviously, the land environment cannot be managed in isolation of coastal and marine environments. Land use on Hawaii's mountains affects nearshore waters through erosion, runoff and sedimentation; therefore, it is important to consider resource protection in terms of linked ecosystems rather than political boundaries.

Lack of Site-Specific Management Plans

Effective protection of Hawaii's unique and/or significant natural areas — including estuaries, anchialine pools, wetlands, beaches, corals and unique shorelines and underwater geologic formations — requires site-specific management plans, tailored to address the specific concerns of individual areas. Without clear management policies at the State and County levels and without site-specific plans, many of Hawaii's unique and significant resources of aesthetic, recreational and economic value are being degraded at the public's long-term expense.

Lack of Coordination in Management of Protected Areas

Federal, State and County agencies have management authority over individual areas and resources of Hawaii's marine and coastal environments. Despite the natural linkages, there has been little effort, until recently, to coordinate their management. For example, the nearshore waters adjacent to coastal County parks are not protected by the State. At Kaloko-Honokohau National Historical Park, Federal and State officials are attempting to develop a coordinated management system for adjacent nearshore waters. However, this process is slow; management jurisdiction and regulations are not settled.

Within the State park system, two Underwater Parks have been named. However, since they are also MLCDs, they are not managed as State parks. There has been no attempt to expand management and enforcement of these areas by combining the efforts of DLNR's Divisions of Aquatic Resources, and State Parks.

Inadequate Management of Important Marine Species

Coastal developments often compete for the use of important resource habitats. However, without data on the locations of "critical habitats" for endangered or threatened species, restrictions on coastal developments often are not considered justifiable. There is growing recognition of the need to protect the habitats of these unique resources, such as humpback whales and sea turtles. There is also an increasing awareness of the need to regulate activities on land that affect, directly and indirectly, critical marine habitats. Though current laws discuss the need for habitat protection, complete data regarding habitat locations are lacking.

Other marine species, which are not protected under natural resource laws, are being harvested at a growing rate. For example, the collection of finfish, shellfish and mollusks for the aquarium industry is a flourishing activity, risking the depletion of these important species. The protection of these unprotected species and their habitats is a growing public concern in many areas of Hawaii.

Overuse of Certain Natural Resources and Areas

Many of Hawaii's marine protected areas, such as Molokini MLCD and Hanauma Bay MLCD, are over-used (DBED 1990). While the goal of the Marine Life Conservation Program is resource protection (Chapter 190, HRS), some of these areas have become tourist destinations promoted by private interests. There has been little effort to reduce use-levels because of DLNR's support for the public use of these MLCDs. Typically, DLNR has been reactive, as in the case of Molokini MLCD, where blocks for mooring buoys were dropped to eliminate safety hazards only after the situation became a crisis.

Inadequate Enforcement

The number of personnel available for enforcing regulations in existing protected areas is inadequate. The National Marine Fisheries Service has four people available for the entire Pacific area, including Hawaii. As already noted, DLNR, Division of Conservation and Resource Enforcement, has a limited number of enforcement personnel on each of the main Islands (21 on Oahu, 15 on Maui, 11 on Kauai, 15 on Hawaii). DOCARE personnel are responsible for enforcement in both marine and terrestrial areas; none are specifically assigned to marine protected areas.

Inadequate Research and Monitoring Programs

Given continuing or increasing levels of development, monitoring the effects of such development on the nearshore environment is essential. Current water quality monitoring efforts by DOH provide useful, but not comprehensive, information.

Also, DOH monitoring is not site-specific to protected areas. While general government funding for monitoring programs is limited, there are private programs — such as at resorts — and specific governmental programs — such as at the Natural Energy Laboratory of Hawaii — which do monitor water quality. However, these programs are not coordinated and an overall water quality picture is not available (see Waste Management Technical Paper).

Marine-life monitoring programs also are limited. DLNR, Division of Aquatic Resources, only conducts annual surveys on fish biomass in marine protected areas. More frequent and regular monitoring of marine resources within protected areas is needed. Monitoring parameters such as coral growth and extent of coral cover also is essential in determining the health of a marine ecosystem. Currently, this type of monitoring is not done on a regular basis in any protected area.

Complementing the monitoring programs, specific research topics need to be addressed, including the identification of critical habitats for endangered and threatened species and pinpointing of the cause of ciguatera poisoning in fish. While several university research projects are underway, more studies are needed to focus on meeting specific management objectives. Furthermore, research on the impacts of coastal development on nearshore ecosystems must be expanded.

Inadequate Public Involvement

Though there are means for the public to comment on the State EIS process, SMA permit requests and the Conservation District permit-granting process, the public does not have an effective means for commenting on Environmental Assessments or Negative Declarations. Likewise, while the public has an opportunity to comment on NARS site selections, the means is not effective.

At this time, community education programs aimed at increasing public awareness of and participation in marine and coastal resource issues are few in number. The development of such programs to expand the public's role in marine conservation would nurture a respect for the natural environments of Hawaii and, thus enhance resource protection.

RECOMMENDATIONS

Objective

Provide for protection of marine and coastal ecosystems, and establish a comprehensive system of marine and coastal protected areas within an integrated program which protects, preserves and enhances marine species and areas of exceptional resource value on each main island, representing each of the natural ecosystems and resources found in the marine and coastal environment of the State.

Policy A

Expand protection of species, natural habitats and other resources of exceptional value, thereby minimizing environmental degradation from marine and coastal activities and uses.

Implementing Actions:

DLNR and OSP should:

1. Prepare a comprehensive and cohesive statewide master plan for marine and coastal protected areas which can be incorporated into an overall management plan in order to balance protection and use of marine and coastal resources. The master plan should both expand upon the existing system and incorporate new types of marine protected areas which will protect such features as unique underwater geological formations and archaeological sites, as well as coastal areas from which whale-watching and other coastal-recreation activities can occur. This planning process should include at least the following actions:

   a. Convene a State policy and management workshop to establish criteria for selecting marine and coastal protected areas.

   b. Identify areas of exceptional resource value which should be considered for protected area status. This inventory of unique and representative examples of natural ecosystems and resources found in Hawaii's marine and coastal environments can be prepared as part of the overall coastal resources inventory within the State's Geographic Information System (GIS) program. Identify natural areas in need of restoration, prioritize these areas, and implement restoration programs.

   c. Establish a system of marine and coastal protected areas throughout the State to protect the best examples of these natural ecosystems and resources on each island.

   d. Establish site-specific management plans, within the framework of the statewide master plan, for each marine and coastal protected area, using a methodology such as "Limits to Acceptable Change" to establish appropriate carrying capacities. Include within these plans descriptions of allowed commercial and recreational uses.

   e. Uphold the original goal of the Marine Life Conservation District (MLCD) program, which is resource protection, by establishing use-limitations so that marine resources within these districts are adequately protected. Those current MLCDs that are intensely used are more appropriately managed as underwater parks; new MLCDs should be designated for protection of marine resources. The original goals of the Natural Area Reserve System (NARS) and Fisheries Management Area (FMA) programs should also be upheld.

   f. Review the existing State Seabird Sanctuary system to determine appropriateness of rules and management policies and feasibility of adding new units to the system to protect seabird and other wildlife resources.

g. Establish a statewide system of day-use mooring buoys to protect reefs from anchor damage. DOT is presently working with The Ocean Recreation Council of Hawaii (TORCH) and the Mooring Pin Advisory Committee on this project, as required by House Concurrent Resolution No. 21, 1990. [See Ocean Recreation section]

h. Identify species of high commercial and recreational values and provide these species and their habitats with adequate protection to ensure the continued economic viability of their dependent industries.

i. Continue working with the aquarium fish collecting industry to develop a management plan which establishes guidelines and regulations of collection at a given site and limits to collection of certain species.

2. Request the Legislature to increase funding to: DNLR State Parks Division in order to improve the management of underwater parks; and DLNR Division of Forestry and Wildlife in order to improve management and enforcement of the State Seabird Sanctuary system.

3. Work with the Counties planning commissions, and planning departments (City Council and DLU for the City and County of Honolulu), to establish coordinated marine life and water quality monitoring programs to provide a comprehensive data base regarding the quality of Hawaii's marine and coastal resources. As part of these programs:

a. Require monitoring before, during and after construction of coastal developments in order to obtain a better data base for understanding the numerous and cumulative impacts of these coastal developments on fringing reefs, anchialine pools and other natural resources.

b. Support research into the effects of coastal development on the quality of nearshore waters and marine life.

4. Establish an effective program for handling spills of oil and other hazardous substances in order to minimize damage to the marine and coastal environments. [See Waste Management Section.]

5. Coordinate with and encourage Counties planning departments (DLU for the City and County of Honolulu) to:

a. Establish appropriate development controls for areas inland of marine and coastal protected areas to prevent non-point source pollution through runoff or groundwater contamination.

b. Incorporate habitat protection of endangered and threatened coastal and marine flora and fauna into County planning efforts.

c. Ensure that protection of open coastal spaces is included in County plans.

d. Evaluate development along entire river watersheds to ensure that estuaries will not be receiving large amounts of cumulative pollutants.

6. Evaluate the feasibility of leasing submerged lands to private, non-governmental organizations (eg., the Nature Conservancy) for management as a marine protected area.

Policy B

Facilitate coordinated and comprehensive inter-agency management where jurisdictional overlaps exist between Federal, State and County governments in marine and coastal protected areas.

Implementing Actions

DLNR and OSP, in conjunction with appropriate Federal, State and County agencies, should:

1. Coordinate with Counties in designating and managing marine protected areas adjacent to coastal County parks, coordinate with NSP and FWS in designating and managing marine protected areas adjacent to coastal National Parks and National Wildlife Refuges, and coordinate with other State agencies in designating and managing marine protected areas adjacent to coastal State parks.

2. Facilitate and coordinate Federal, State, and private-cooperative research and monitoring efforts at developing baseline information regarding the locations of critical habitats of endangered and threatened species. Encourage the designation of these critical habitats as protected areas.

3. Encourage joint efforts of Federal, State, County, private and community involvement in marine life and water quality monitoring programs.

4. Organize statewide management workshops with Federal, State, County and private managers to address significant issues and develop improved management tools such as:

a. A policy for protecting wetlands from development

b. A strategy for maintaining open ocean space.

c. Other policies governing the uses of resources of shared interest.

Policy C

Improve the enforcement of regulations protecting marine and coastal protected areas and species.

Implementing Actions

DLNR should:

1. Request the Legislature to increase funding for enforcement of marine conservation and preservation regu-

lations to provide more personnel and equipment for more comprehensive enforcement.

2. Request the Legislature to increase funding for management and educational programs addressing marine and coastal protected areas and species; and encourage Federal and private funding of such efforts.

3. Establish Memoranda of Understanding (MOU's) between Federal and State agencies to enable personnel from these agencies to enforce both State and Federal regulations.

4. Coordinate community and private-sector involvement in monitoring and enforcement of regulations.

5. Budget funds to staff and publicize the toll-free number available to the public to report sighted violations of regulations. This should be done in cooperation with the existing NMFS program for reporting violations of regulations concerning marine mammals and sea turtles.

6. Identify remote areas in need of more frequent patrolling.

7. Review penalties for adequacy and appropriateness.

Policy D

Enhance local community awareness, appreciation, and participation in marine conservation and preservation efforts.

Implementing Actions:

DLNR should:

1. Request the Legislature to appropriate funds for improving public education programs in schools and elsewhere, to increase public awareness and appreciation of marine resources and conservation. [See Ocean Research and Education section.]

2. Encourage public participation programs such as "Coast Watch" or "Adopt-a-Shoreline" as ways to enhance public understanding of marine conservation and enforcement of rules.

3. Encourage programs which emphasize the cultural and historical values of Hawaii's marine and coastal resources. For example, seek programs which revitalize ancient Hawaiian fishponds to grow *opae'ula* (red shrimp) using traditional methods as a means of historical preservation. This must include solving siltation and runoff problems, and could be a part of interpretive programs at parks or resorts, rather than as commercial ventures.

4. Facilitate the process for public comment on the adequacy of Environmental Assessments and on Negative Declarations.

5. Facilitate the process for public comment on adding to or removing lands from the Natural Area Reserve System.

6. Change the administrative procedure to allow for a public comment period for species recovery plans.

7. Encourage public involvement in the development of overall and regional ocean and coastal management plans.

8. Support the development of interpretive centers, especially at protected areas, to educate the public on the uniqueness of Hawaii's marine resources. [See Research and Education section.]

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BEACHES AND COASTAL EROSION

THE RESOURCE

Worldwide, the typical image of Hawaii is of beautiful white sand beaches lined with palm trees. Hawaii has majestic mountains and famous volcanos, but the areas most valued — treasured by visitors and residents alike — are coastlines. Ironically, the very desirability of those coastlines for recreation, vacationing and residence has resulted in human activities that threaten future enjoyment of them.

The threat in a word, is erosion. Whereas erosion is a natural process, and not usually a problem in the absence of human development, human development along the coastline has increased both erosion and the risks to life and property as a result.

Many people now recognize the resource value of beaches and shoreline property. Millions of tourists come to the Islands every year just to enjoy the beaches. Residents, as well as visitors, use Hawaii's beaches for recreation. On an average day, at least 170,000 people swim or sunbathe at beaches in Hawaii (see Ocean Recreation Technical Paper). Shoreline residences are among the most prized real estate in the nation. Hotels, condominiums, apartments and homes on the shoreline, and especially close to beaches, are of premium value. A home or condo on the beach is considered by many to be a luxury because of the proximity to this resource.

Not often considered is the importance of beaches as a resource for other purposes, such as wildlife habitats, energy buffers, and as a source of sand. Ecologically, beaches and nearshore marine waters are habitats for many seabirds, turtles and other animals that nest or breed on beaches or dunes. Communities of crustaceans inhabit certain beaches and attract shorebirds. Sea turtles come ashore to lay their eggs above the high water line on a few remote beaches, primarily in the Northwestern Hawaiian Islands. The Hawaiian coastline also supports unique beach ecosystems, called "strand" ecosystems, which contain rare endemic and indigenous forms of plant life.

Most people are unaware of the critical role that coral reefs[1] and beaches play as energy buffers. Sandy beaches are particu-

larly important for protecting inland areas from storm flooding and damage from wave run-up. Sandy beaches have a dynamic relationship with wave energy levels: sand can be both deposited (e.g., during the relatively calm summer) and eroded (e.g., during winter storms). This suggests the importance of sand in nearshore areas. Nearshore sand is an integral part of a beach system, with sand moving on- and offshore depending on wave action and currents.

Historically, beaches also have been a source of sand for human activity, mainly construction. Removing sand from one area of a beach system, as is done in sand mining, can cause erosion problems in other areas of that system. Shoreline sand mining occurred for many years, for example at Waimea Bay on Oahu and Papohaku Beach on Molokai, but removal of sand from beaches now is severely restricted.

Physical Processes as Resources

The Hawaiian chain generally is believed to have been formed by the tectonic movement of the Pacific plate over a "hot spot" in the Earth's crust. This hot spot created a succession of volcanos as the plate moved toward the northwest. Thus, the oldest of the eight major islands is Kauai and Hawaii is the youngest. Correlated with age, Kauai has the most extensive beaches and Hawaii has the least.

Coastlines consist of sea cliffs (e.g., Na Pali Coast), sandy beaches, mud flats, raised coral reefs, and some areas of mangrove. Bay formations are generally the result of river valleys drowned by post-glacial sea-level rise or embayments between adjacent volcanos (OSP 1989). Long stretches of sandy beaches are found on all the major Islands, except for Kahoolawe and Hawaii. Pocket beaches formed between rocky headlands or sea cliffs are the most common type of beach found on the islands of Kahoolawe and Hawaii. Pocket beaches are found on all Hawaiian islands.

Erosion and accretion are natural processes. In many areas, sand is moved from place to place[2] along the shore and within the nearshore area by wave action and coastal currents as part of an annual cycle of erosion and accretion. This type of erosion is especially noticeable at north shore beaches because of large seasonal differences in wave action. Hawaiian coastlines also experience cyclical erosion,[3] in which an area may erode for a number of years and then accrete for a number of years.

The key processes that drive littoral changes include winds, currents, waves,[4] tsunamis,[5] hurricanes[6] and seasonal storms. Storms can produce the most profound and dramatic erosion and damage effects. Large storms that coincide with high tides often do the greatest damage. Storm waves under these conditions are able to strike the coastline at greater heights and with greater energy.[7] Not only are these types of storms a threat to buildings and other coastal developments, but they also have great potential to carry large volumes of sand offshore and along the shore (COE 1979). Such storms, although they may only occur once a decade, can have significant impacts along the shoreline.[8] The winter storms of 1968 and 1969 are examples of this type of storm (Hwang 1981).

Long-Term Erosion Trends

Beach sand in Hawaii originates from three sources: erosion of volcanic rock on land, fragmentation of coral reef materials and associated shells of organisms, and, rarely, fragmentation of lava flowing into the ocean. The primary source of beach sand on the older Islands is from the fringing coral reef (COE 1979). While the composition of typical beach sand includes both calcareous and basaltic materials, the predominant components are fragments of skeletal parts of marine invertebrate animals and algae. The most common skeleton fragments belong to *foraminifera*, followed by mollusks, red algae, and echinoids (Moberly and Chamberlain 1964). Coral fragments have been found to be fifth in order of prominence in calcareous sands and are thought to be declining as a source of sand due to overfishing of parrotfish and other grazing fish that bioerode coral skeletons (OSP 1989). The other major source of beach sand is eroded basaltic material from the land surface, which are either fragments of bedrock or minerals.[9]

Human intervention in the coastal zone clearly has had a major impact on the natural processes of erosion and accretion. The "hardening" of the shoreline,[10] particularly on Oahu (e.g., the shoreline fronting the Diamond Head end of Kalakaua Avenue in Waikiki), has had such a critical effect that some beaches may never recover. As previously mentioned, overfishing of coral grazers may have a long-term negative impact on the generation of sand. The smothering of coral reefs by silt and other kinds of nonpoint source pollution also has a detrimental effect on the long-term health of coral reef communities, and thus their sand-production abilities. Navigation channels cut through reefs not only destroy sections of the reef, but also act as sediment traps, which remove sand from the active littoral zone (Moberly and Chamberlain 1964; COE 1979).

Sand mining also has been an historical activity which has contributed to erosion. Although sand mining is now restricted to beach replenishment efforts, the removal for personal use is still allowed (up to one gallon per person per day). Stream mouths occasionally, often seasonally, become clogged with sand and detritus. Stream and channel mouths are cleared of sand periodically. Generally, the material is placed on adjacent shoreline areas although sometimes it is removed from the littoral cell entirely.

At a global level, human interventions in natural processes may have an even more profound impact on Hawaii's coastline. Global climate change may have a range of possible long-term consequences including: altered precipitation patterns,[11] altered winds and currents,[12] air and water temperatures;[13] increased frequency and intensity of storms and hurricanes;[14] and an accelerated sea-level rise.[15]

While there is still considerable uncertainty about the extent of possible global warming due to the doubling of carbon

dioxide and increasing amounts of other "greenhouse" gases in the atmosphere, there is widespread consensus that the atmosphere is warming. A similar consensus is growing that global warming will result in an acceleration of global sea-level rise. Both developments, fortunately, are gradual, can be monitored and responded to before their effects have serious impacts on life and property.

Sea-level rise itself is still a controversial topic. There is not much doubt that the sea level will rise. The disagreements are about the extent of the global sea-level rise. Sea-level research has shown that in the last century, the global rise has been somewhere between 8 and 20 centimeters. An average figure many scientists would agree on for the global sea-level rise in the last 100 years is about 15 cm (6 inches).

The threat which sea-level rise poses to coastal erosion is not a direct one, such as coastal inundation, but rather secondary effects that could enhance the worst effects of storm surges, normal winter storms and seasonal ocean wave swells. However, one direct effect of sea-level rise to be considered is what is known as the Bruun rule. According to the Bruun rule for sandy shorelines (on moderate slopes), for every unit up, the sea moves inland 100 units. Thus, even for a one-inch rise in sea level, the high-tide mark moves roughly three yards inland (National Research Council 1987).

Regardless of the uncertainties involved in projecting the extent of possible sea-level rise and effects of global warming, planners cannot avoid taking these long-term factors into account. Over the long-haul, the costs of doing otherwise would be self-defeating.

RESOURCE MANAGEMENT

Federal Authority

Federal authority related to erosion control and management is embodied in the Coastal Zone Management (CZM) Act of 1972 (CZMA), national flood insurance programs administered under the Federal Emergency Management Agency (FEMA), and mandates of the U.S. Army Corps of Engineers (COE).

The CZM Act (P.L. 92-583) was created to provide assistance to and support states in developing programs for managing coastal zones. Shoreline erosion is an explicit issue mentioned in the CZM Act as an area of concern to be addressed by state CZM Program policy. In addition, the Federal CZM office encourages greater levels of cooperation among all levels of government in planning for and management of hazard-prone areas (OSP 1989).

FEMA's mandate is to provide leadership in flood plain management and the protection of wetlands. Congress has acted to mandate FEMA to implement a coastal erosion management program. FEMA has not yet fully exercised its legislative authority in the area, but is exploring erosion management options to be administered through the National Flood Insurance Program (NFIP). Worthy of mention is the Upton-Jones Amendment to the NFIP (PL 100-242, §544), which encourages retreat from eroding coastlines by providing advance payments of certain insurance benefits. [County flood ordinances presently complement certain FEMA-identified flood zone controls, such as guidelines on ground-level construction to allow flood waters to flow beneath elevated houses and to restrict emplacement of flood-deflecting fill (Kanuha 1990).]

COE has jurisdiction in the coastal zone from the mean high water mark seaward to the 3-mile limit. COE permits are required for dredging, mooring buoys, discharge of fill materials, and erosion-control structures, such as revetments, groins, breakwaters and levees. Any individual or entity who plans to do work "in, under, across, or on the banks of navigable waters" must obtain a COE permit. Its regulatory mandate is established in at least nine laws including: the Rivers and Harbors Act of 1899; Fish and Wildlife Act of 1958; Environmental Policy Act of 1969; CZM Act of 1972. While major projects in its jurisdiction require regular COE permits, a "nationwide" permit program is in effect for projects of limited scope. The nationwide program is intended to reduce delay and paperwork for small projects. Between 10 and 30 activities are undertaken annually in Hawaii under COE nationwide permits (OSP 1989).

COE will build erosion-control structures when the long-term benefits over a 50-year period can be justified. COE acts on requests from projects at a local level, but will not develop such structures for purely private interests. Approval for projects generally is not granted until all State and County permits are granted. COE is responsible for an environmental assessment (EA) and, if necessary, an environmental impact statement (EIS) for projects with significant environmental impacts under the Environmental Policy Act of 1969. Permit issuance is dependent upon a review of the EA or EIS, if deemed necessary.

State Authority

State Authority rests in two major pieces of legislation, the State Land Use Law (Chapter 205, HRS) as amended, and Hawaii CZM Law (Chapter 205A, HRS). The State Land Use Law is the cornerstone legislation which, among other things, establishes the four major land-use classifications (urban, rural, agricultural and conservation), and divides the jurisdiction over these lands among State and County governments. Urban districts are under the control of the four County governments. Parcels of 15 acres or less in agricultural and rural districts come under County control. Larger parcels are under State control. Conservation lands are under State control.

The Department of Land and Natural Resources (DLNR) has jurisdiction over conservation district lands, some of which are shorefront. All submerged lands seaward of the shoreline, out to the limit of the State's jurisdiction, are in the conservation district and thus fall under DLNR jurisdiction. The shoreline is defined "as the upper reaches of the wash of the waves, other than storm and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit

of debris left by the wash of the waves (Chapter 205A-1, HRS)." DLNR reviews Conservation District Use Applications (CDUAs) to allow construction or activities in conservation lands (e.g., seawalls and revetments), although the Board of Land and Natural Resources can deny permit applications or attach conditions to them.

The certified shoreline is a critical boundary for the determination of the various jurisdictions. The procedures for certification are specified in Chapter 91, HRS, which determine where the State's jurisdiction begins. Chapter 13-222, Hawaii Administrative Rules, "Shoreline Certifications," was adopted in 1988, to standardize the shoreline certification application procedure. These rules and regulations administered by the Board were promulgated to implement the shoreline setback law and other related laws.

The Department of Transportation (DOT) has authority over activities within State waters (Chapter 266, HRS). Ocean dredging, filling, construction and dumping materials below the mean high water mark (or in any navigable waters) require a DOT permit. A DOT Shorewaters Permit is processed and issued concurrently with a CDUA. The Water Transportation Facilities Division of DOT will provide a written statement concurring or disagreeing with the CDUA/Shorewaters Permit. If DOT does not concur with the CDUA permit approval, the applicant must apply separately for a Shorewaters Permit (DPED 1979).

Chapter 183, HRS, Part IV, Relating to Forest and Water Reserve Zones, gives DLNR authority to establish forest and water reserve zones and to adopt regulations governing them. In 1985, amendments to this law prohibited building structures or seawalls on accreted lands (except State and County properties) and determined that all accreted lands should be considered to be within the Conservation District.

Chapter 205A, HRS, the Hawaii CZM law, has set out broad guidelines and objectives to regulate the State's coastal zone. This law was the result of the authority delegated through the National CZM Act of 1972 to the various coastal states, which in Hawaii is vested in the Hawaii CZM Program. The program is administered by the Office of State Planning (OSP), through a network of State agencies, and the County governments (through the Special Management Areas/Shoreline Setbacks — discussed later). CZM objectives relevant to coastal erosion included provisions: to provide accessibility to recreational resources; protect, preserve and restore scenic and open space resources; protect or minimize disruption of coastal ecosystems; protect life and property from coastal hazards; and to improve the development process, improve communications, and encourage public participation.

The Hawaii CZM Program also mandated OSP to reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence; and, control development in areas subject to storm waves, tsunami, flood, erosion, and subsidence hazard (Chapter 205A, Part III).

Act 356 of the 1989 Legislature, relating to CZM, was enacted to strengthen Chapter 205A. Major amendments included a provision to bring unauthorized seawalls into government shoreline jurisdiction — even if a part is on private land; expansion of the "cause of action provision" (right of individuals to file suit) to include all coastal areas (within the State's jurisdiction) outside of the Special Management Area (SMA); extension of and increase in civil penalties for SMA and shoreline setback area violations; and, extension of County jurisdiction over the area between the mean sea level and the shoreline (OSP 1989).

The Hawaii Environmental Impact Statement Law of 1974 applies to all State, County and private developments within the shoreline setback area. The EA/EIS requirements are triggered when any water or land-use permit applications are deemed to have significant environmental impact, defined as "the sum of those effects that affect the quality of the environment, including actions that irrevocably commit a natural resource, or adversely affect the economic or social welfare" (Chapter 343, HRS). The first agency receiving an application for project approval has the authority to make a negative declaration with respect to the EA, or call for a more detailed EIS. When the EIS is submitted, the agency has the authority to accept it or reject it as incomplete. The Department of Health (DOH) is responsible for environmental quality of State waters (Chapter 342, HRS). The National Pollution Discharge Elimination System is a permit process designed to manage and regulate waste discharge into streams and coastal waters (under the Clean Water Act of 1977). It is administered by DOH. Thus, DOH could become involved in an erosion-control activity such as offshore sand mining for beach replenishment, which could affect water quality.

County Authority

Landward of the shoreline, Counties have jurisdiction under State zoning, SMA and shoreline setback regulations. Under Chapter 205A, the four Counties are required to establish SMA boundaries and an SMA permit process for lands extending from the shoreline to no less than 100 yards inland. Developments within SMAs must conform to the objectives and provisions within the Hawaii CZM Law. The permit-granting authorities are the planning commissions for Kauai, Maui, and Hawaii Counties and the City Council for the City and County of Honolulu. Applicants for an SMA Use Permit must file a document that includes an identification of the property, plans, description of the proposed development, shoreline survey (if on the shoreline), and a description of the environment affected. Evidence must be provided that there are no serious environmental or ecological impacts. SMA permit application triggers a review by the designated agency, based on its value (major permits are required for projects over $65,000) and potential environmental impact.

The Shoreline Setback Law (Chapter 205A, HRS, Part III) is most applicable to shoreline erosion impacts. Similar to the SMA process, authority is delegated to the Counties to establish setbacks no less than 20 feet and no more than 40 feet inland

from the shoreline (although counties may extend the setback further by County ordinance). The law is intended to control development on the shoreline, maintain open space and preserve public access to the shoreline. By restricting shoreline construction, the law reduces the long-term threat of erosion and allows for erosion-control structures when erosion threatens private property. Administration and enforcement of the shoreline setback requirements are the responsibility of the County planning departments (Kauai, Maui, Hawaii) and the Department of Land Utilization (DLU) of the City and County of Honolulu. Variances for prohibited activities and structures may be issued following a review by the County authorities. Variances may be granted with conditions attached by the responsible County planning department. The primary intention of the variance procedure is to minimize the interference with natural shoreline processes. However, this provision is considered secondary to private property protection (DPED 1979).

MANAGEMENT ISSUES

Management issues associated with the coastal erosion sector in Hawaii fall into four major categories: resource sustainability; use conflicts; ineffective management and coordination; and participation and education.

Resource Sustainability

There are two major approaches to dealing with erosion when it becomes a problem. The first focuses on efforts to manage the physical form of the shoreline. Shore stabilization structures are designed to protect shorefront property and are referred to as "hardening." The other approach to erosion management recognizes the dynamics of natural shoreline processes and is referred to as the "soft" approach. This approach includes planning efforts such as zoning, shoreline setbacks and special design requirements. Imbedded in these approaches is a conflict: one emphasizes interference with natural processes to protect private property, while the other emphasizes planning and design with nature in mind.

Hardening

Physical techniques and structures widely used to control erosion processes include: seawalls, groins, bulkheads, revetments, detached breakwaters and sand-grabbers. The effect of hardening on an increasing percentage of state beaches (particularly on Oahu) has been labelled "fortress-building" for good reason. The trend can be seen clearly on aerial photographs. Future problems at current chronic erosion sites are likely to continue to provoke proposals for more erosion-control structure. The continuation of hardening over the long-run comes with considerable costs. One cost associated with stabilization structures is the possible transfer of erosion problems to neighboring shoreline properties, resulting in the need for similar measures by downshore property owners. The net effect of these structures (especially seawalls) is often to reflect wave energy, which causes sand scouring and carries sand offshore. As a result, these structures may block lateral shoreline access, and can create hazards for people swimming, surfing or sailing.

A similar cost is associated with the use of groins in some places. First, accretion up-drift and erosion down-drift of the structures occurs. Second, the groins may reduce the strength of the long-shore current. Finally, the groins have combined to reduce or cut off the sand feeding the area. Dennis Hwang (1981) pictorially illustrates how this has occurred at Kualoa Point on Oahu. Another cost may be the false sense of security that seawalls and revetments provide. While most stabilization structures (e.g., on much of Oahu's North Shore) may handle normal winter waves, during large storms or tsunamis, the structures may be topped or damaged. The threat to life and property may be greater than if the structures had never been built. Over the long term, shoreline structures can be damaged "under normal conditions" simply by the incessant pounding of the sea. Major storms also can alter the offshore morphology, thus changing coastal processes and rendering these protection structures ineffective.

Even when people are committed to the construction of erosion-control structures, there are some serious management considerations. To address the structural and functional requirements for erosion projects there should be adequate knowledge of the environmental site conditions; adequate knowledge of the short and long-term littoral processes; adequate design of the structure; proper construction and maintenance; and goals or priorities that may constrain the selection of a particular measure or structure (OSP 1989).

Soft Approaches

For the most part, these approaches are in the interest of preserving the sandy beach resource, although private property generally has higher precedence. Some of the approaches, such as beach fill and beach nourishment, border on the hard side (as earthmoving processes), but are considered less damaging (even supportive) of natural littoral processes. Renourishment of eroding beaches with sand, construction of barrier dunes and planting vegetation along unstable beaches are other physical alternatives for controlling the effects of erosion. These approaches are less invasive, soft techniques for stabilizing beach processes. These nonstructural methods have been under-utilized and beach replenishment projects are impeded due to regulatory hurdles (DPED 1979).

Sand mining is clearly an issue related to both beaches and shoreline erosion. Conceptually, sand from mining operations can be removed from the littoral area or placed in it. For the most part, sand has been mined for use as a construction material. Sand for this purpose has come from beaches and sand deposits (e.g., "relic dunes") mauka of the shoreline boundary. More recently, sand from a third geographic area — offshore deposits — has been explored as a possible source for beach replenishment (as well as for commercial purposes). Sand mining is restricted, but may now be authorized for public

uses by a Shoreline Setback Variance. Relic dunes within the SMA (outside of the shoreline setback area), can be mined if an SMA permit is obtained. The most critical issue facing the mining of off-shore sand for beach replenishment (other than cost), is the plethora of regulatory hurdles. Among the hurdles that could be required to replenish an Oahu beach are: CDUA, SMA, EIS, DOH Water Quality, COE and DOT permits; DLNR Land Management Division approval, as well as approval of the City Council.

Shoreline setbacks are examples of soft regulation, yet the setback variance process allows measures of the hard sort. However, as Hwang pointed out a decade ago, 40 foot — let alone 20 foot — setbacks in some areas are of little value in protecting against erosion. He pointed out that Counties have the power under Chapter 205A to regulate new development within the 100-yard SMA. Rolling back the setback boundary for new developments could be carried out within the current regulatory framework (Hwang 1981). A related set of issues pertains to the need for the State and Counties to act to create special zones (i.e., hazard zones or coastal erosion districts) to vary setbacks in the absence of the political will to roll them back to a standard limit (e.g., 100 to 300 feet).

Use Conflicts

As illustrated above, erosion problems often raise debates over public-versus-private property rights. This is the key issue that poses one of the greatest challenges to erosion management. For example, the legal issue of "taking" often arises when the government is perceived to be infringing on private property rights or effecting property values. Use conflicts are not confined solely to tensions between public and private interests, and can include private-private and public- public conflicts as well.

Public-private tension is the central conflicting-use issue. Lands seaward of the shoreline (the vegetation line or upper wash of the waves evidenced by a debris line) are open, public-use areas. As a result of erosion, the outer boundary of public-use areas is pushed inland, thus shrinking that zone. The reasoning is that erosion-control structures built within the shoreline setback establish a firm boundary for a private property parcel, while the shoreline — vegetation line and/or upper wash of waves — continues to move inland up to the toe of the structure. If left to erode naturally, the beaches generally maintain a normal profile. In these cases, the public-use area is maintained, but there is no compensation to the private owners for their loss of property. Clearly the inclination of property owners is not to abide the processes of nature, and shore protection structures are put in place to stabilize the shoreline and maintain the private, upland property.

Given the general tendency towards shoreline hardening to protect private property, it is usually public areas that are reduced in size over time. The construction of erosion-control structures, such as seawalls and revetments tends to reduce the "public" area. It may prevent lateral access altogether, as mentioned earlier (see Ocean Recreation Technical Paper). This may happen gradually, but once the beach is totally eroded at the toe of the structure, access is prevented. The tendency toward hardening not only blocks lateral shoreline access, but also creates hazards for recreational activities. One factor that exacerbates the strength of public feeling about the issue is the perception (often true) that many structures are constructed improperly and/or illegally. Shoreline access is a critical issue. It is one of the key objectives of the CZM Act and it is a high profile issue for the general public.

The loss of lateral access due to hardening is a serious issue highlighted at the time of this writing by a court case involving a seawall proposed for a stretch of Lanikai beach on Oahu. The Lanikai case also reflects another conflict area, a private-private tension. Some Lanikai shoreline residents are concerned that seawall construction will accelerate erosion on neighboring properties. Thus, an example of private- private use conflict is where construction of a seawall or revetment by one owner can result in loss of sand from neighbors' properties.

Larger private developments also may create erosion problems resulting in both private-public and private-private conflicts, although this appears to be less of a problem than haphazard residential seawall construction. Similarly, large public works projects, such as marina developments and/or entrance channel projects, may alter littoral sand cycles and thus have long-term consequences both for private and public beach properties (see Harbors Technical Paper).

Thus, what might be considered a laissez-faire approach to structural stabilization conflicts with the "public trust". A list of public trust concerns includes: governmental responsibility to protect citizens from natural hazards; long-term erosion "externalities" (i.e., costs of property loss, construction and loss of tax revenues); uncoordinated individual actions with unintended consequences (e.g., physical impacts on public lands and resources); long time-horizons and a disproportionate share of costs transferred to future generations; and the public's "right to know" in the case of proposed developments in erosion-sensitive areas (OSP 1989). Noda points to the need to see erosion management as part of a larger set of policy initiatives "involving open space preservation, beach access, shoreline development and ocean resource management" (OSP 1989, 3-14)

Ineffective Management and Coordination

Resource Issues

The lack of financial and human resources has been identified as a problem in the area of erosion management, particularly in enforcement (OSP 1989). At the County level, there is insufficient budget and personnel for adequate inspection and monitoring of erosion-control structures. Coastal engineering expertise is needed within line agencies, not just through occasional consulting studies. There is also a clear need for other technical specialists in the coastal zone management network or available to it. Hawaii is, in fact, the only coastal state without a state geological survey (Moberly 1990). There have been continuing problems in recruiting and retaining this

type of specialist in government. This is by no means a problem unique to erosion management, but it is a problem that complicates effective shoreline management.

Enforcement Issues

Although it appears that enforcement is a statewide problem, the City and County of Honolulu has the largest problem. One of the more dramatic areas, which exemplifies this management problem, is Lanikai beach. On one stretch, there are 36 lots, only three of which have not had seawalls built on them. Only two were built with the proper permits. Nine seawalls are "non- conforming" and 22 are considered illegal (OSP 1989, 3-14). Studies have called for greater monitoring (e.g., from oblique aerial photographs) to detect illegal structure and for the need to take sanctions against violators. Whereas the Counties now have greater jurisdiction, at the time of this report, violators are still not being fined for illegal seawall construction.

Enforcement has been problematic because of the difficulty in identifying illegal structures. Considerable energy is spent in the process of inventorying existing shore structures and in researching permit histories. Records need to be searched at all three levels of government (Federal, State and County) because it may not be possible to tell what agency had jurisdiction at the time of construction. Clearly, the lack of funding and staffing for enforcement are significant issues. High litigation costs are another major contributing factor limiting the level of enforcement.

Research Issues

Enforcement is clearly linked with the need for more research and better coordination of shoreline data and beach databases. In addition to monitoring shoreline lots on Oahu, statewide monitoring and shoreline surveys and monitoring are needed. Baseline data are needed for offshore bathymetry and coastal morphology. Long-term time-series studies are needed to establish baseline erosion rates, including site evaluations as well as fine-grained photographic and cartographic data- gathering. Risk assessments still are needed to isolate specific high-risk erosion and hazard areas for site-specific time-series research.

Shoreline Boundary Issues

In 1989, legislation providing that the Counties may extend their shoreline jurisdiction seaward to the mean sea level was an important step toward untangling the jumble of overlapping jurisdictions, blurred jurisdictional boundaries and shifting physical boundaries of the shoreline. One continual source of complications has been that natural boundaries shift and change, while the regulatory boundaries tend to stay the same. Historically, differing definitions of the shoreline have posed problems, and have changed over time. For example, shoreline jurisdiction boundaries may be defined as the highest wash of the waves, the mean sea level or the vegetation line.

Shoreline certification has been one focal point of the erosion management problem. The purpose of shoreline certification is to define the shoreline to implement the shoreline setback law and other related laws. A number of problems remain: the issue of "ownership," the accuracy and efficacy of the certification process, "emergency ordinances" following coastal erosion events, and subdivisions of accreted lands and within shoreline setbacks. In the first place, State certification of the shoreline does not deal at all with the problem of ownership of the lands in question. Shoreline certification only establishes (for one year) the boundary of the setback and SMA. Thus, while the consequences of certification generally mean that the makai side is public and the mauka side is private, it does not always establish the legality of "ownership." For example, if erosion or accretion occur, the State can recertify the shoreline, but cannot decide ownership questions.

Another problem is that when shorelines are surveyed during calm weather, the shoreline certified usually does not reflect the statutory "upper reaches of the waves...at high tide during the season of the year in which the highest wash of the waves occurs..." This is particularly true for the Island of Hawaii where wave wash-up is considerable, and evidence for the "upper reaches" is not as clear, given the generally younger geology of the shoreline (Kanuha 1990). In cases where the shoreline is lost "due to subsidence due to earthquake, or storm or tidal wave," the shoreline may be certified at or near the location of the earlier shoreline and the property owner may apply to restore the shoreline at its previous location. There is serious concern about this process on the part of environmentalists and planners who think that it sets the stage for even more problems in the future, including possible loss of life.

Subdivisions of land within the shoreline setback area also have become a problem. Some wide, shallow lots where resulting subdivision means that there is little buffer between structures and the shoreline. "Hardship" setback variances are much easier to obtain for erosion-control structures when lots are shallow.

Coordination Issues

The lack of interagency coordination of erosion management and permitting has had a number of consequences. For example, some property owners, faced with the possible red tape in dealing with three levels of government opt to build seawalls solely on their own property. Although they only have to get a setback variance (and thus avoid Federal and State permits), the smaller space available for a structure favors the selection of a seawall, which is likely to lead to greater erosion.

Physical boundaries can change to complicate matters further. Construction of shoreline-stabilization structures seaward of the shoreline may result in the movement of the shoreline to the toes of the structures. Thus, a structure constructed in the jurisdiction of DLNR may eventually fall under County jurisdiction. This is one reason why a coordinated State/County system for managing shoreline stabilization structures is needed.

COE's "nationwide" permit system has streamlined the process of obtaining a Federal permit for minor work in the coastal zone, and as a result is often considered the easiest permit to obtain (OSP 1989). Because obtaining a nationwide permit is relatively easy, many people apparently believe it is the only permit necessary. Despite the fact that COE informs permit recipients to check with the local permit-granting agencies, many people do not obtain the additional necessary permits. COE forwards copies of its permits to local agencies, but there is no formal information-sharing process. Similarly, State and County agencies do not consistently inform COE about permits that also fall in COE jurisdiction.

Coordination is also a problem at the neighborhood level. There has been a serious lack of coordination with or among residents with respect to the alignment and littoral coordination of structures. Sea Engineering cites the Punaluu area (of Windward Oahu) as a good example, where erosion structures are well-constructed, generally of the same type, and have consistent alignment. By contrast, a section of Oahu's Laniloa beach has eight different types of structures, with varying alignments, and the "overall appearance of the shoreline is poor" (DLU 1989, 23).

Participation and Education

The remaining, and perhaps most significant, management problems are all closely interconnected. Public participation in the erosion planning and management process is virtually nonexistent. Public education on erosion is virtually nonexistent. A perspective that looks to the future is lacking, as well, in the one area of ocean resources management where it is called for most. These factors are generally ignored, but together, would spell success in forging a proactive and cohesive alliance of interests to work with the shoreline instead of against it.

Public participation at a meaningful level is needed to overcome resistance to changes in shoreline erosion management, which may be required. Tough choices like "private property versus public beaches" will have to be addressed squarely. Broader public awareness, greater knowledge of coastal processes on the part of shore-dwellers, and legislative expertise are required if managers are to make headway against the loss of the coastline. Shoreline property owners have to come to terms with the prospect of losing the "image of Hawaii" — permanently. This has to do with more than just fewer beaches for residents to enjoy. The image — and the tourist industry that depends on it — relies on a continued future for abundant sandy beaches.

The myopia of the present is our biggest enemy in the struggle to save our land and our beaches. A long-term perspective of the future and the environment is absolutely necessary to the successful management of these resources. More than any other section within the Ocean Resources Management area, coastline erosion requires a broad time frame of understanding. One must see the decades and centuries-long processes at work, and appreciate the long-term costs (from hardening) that are being passed to future generations. For example, Kailua, Oahu residents might benefit from knowledge about tradewind patterns over the long-term. Evidence suggests that tradewinds shift direction from northeast to east and back to the northeast over a period of 40 years. If this periodicity continues, Kailua beach erosion/accretion also may have a natural 40-year cycle (Hwang 1981).

Public education is intrinsic to public participation in the planning and management process (a CZM objective) and to the cultivation of a future-oriented perspective. The low level of public participation and public education, coupled with the lack of a long-range planning component in policy and management points to continued and escalating conflicts and costs. Unless Hawaii becomes more anticipatory, its people will be unprepared to deal with the serious concerns that will be posed by global warming and sea-level rise over the next two decades. The absence of an engaging information and public education program will allow widespread public apathy toward a number of ocean and coastal issues to continue.

Hawaii needs to stay on the "cutting edge" of national coastal zone management. Of the 29 states with CZM programs, only 13 including Hawaii, have setback regulations specifically for erosion. Hawaii has been in the forefront of coastal management in a number of areas. However, other states, such as North Carolina and Florida, have more aggressive and larger erosion management programs. As a leading coastal state, Hawaii should provide an example of how to be forward-looking, particularly with regard to erosion. As an island state, Hawaii has the opportunity not only to influence the other coastal states, but also to serve as an example for island countries around the world.

RECOMMENDATIONS

Objective

Develop an integrated State erosion management system that ensures: 1) the preservation of sandy beaches and public access to and along the shoreline; and 2) the protection of private and public property from flood hazards and wave damage.

Policy A

Establish and maintain a comprehensive coastal shoreline survey, database, and other research.

Implementing Actions:

OSP, in cooperation with DLNR, should:

1. Give high priority to the identification and characterization of chronic erosion and inundation areas throughout the State so that regulatory and structural mitigation measures can be implemented as soon as possible.

2. Establish and maintain a statewide database for aerial photography and coastline studies, and classify each area of the shoreline according to level of erosion and inundation risks.

3. Set priorities for and monitor basic research on beach processes, littoral cell sand production and movement,

risk assessments [see Policy D], and baseline coastal erosion and cartography.

4. Obtain standardized and digitized data from University and other researchers for inclusion in the statewide ocean and coastal Geographic Information System (GIS).

5. Provide for easy access to data and databases both for resource managers and the general public.

6. Further identify and inventory offshore sand resources.

7. Carefully examine the application of the Bruun rule (i.e., that sea-level moves inland up to one hundred units for every one unit of rise) to various shoreline types across the State based on a range of possible scenarios for sea-level rise.

Policy B

Coordinate County, State, and Federal erosion- and beach-management efforts.

Implementing Actions:

OSP should:

1. Work cooperatively with the Counties and other State agencies in establishing and implementing a consolidated permit application, review, and approval system for erosion-control structures and setback developments.

2. Explore regulatory and economic incentives, including strategies being used in other coastal states such as:

   a. Tax incentives;

   b. Insurance rates;

   c. Hazard ratings.

Policy C

Exercise greater enforcement of laws and regulations.

Implementing Actions:

DLNR should:

1. Work closely through their representatives to implement a uniform permit system. [See Policy B, Action 1.]

2. Collaborate with and act on recommendations to limit erosion-control structures.

3. Increase the level of negative sanctions to be applied against law and regulation violators (including structure demolition, fines, and other civil penalties).

4. Seek greater funding for personnel, site visits, and monitoring of shoreline alterations. [See Policy I.]

Policy D

Ensure the continued natural production of sand and assess the potential for using beach replenishment.

Implementing Actions:

OSP, in cooperation with DLNR, DOT and the Counties, should:

1. Continue scientific research programs to explore the mechanisms and to assess the current rates of sand production.

2. Select non-rural hazard areas and chronic eroding and unstable beaches for sand replenishment pilot projects and monitor impacts on littoral cell dynamics.

3. Establish projects to stabilize littoral cell sand balance in hazard, chronic erosion, and unstable areas by:

   a. Removing unsound erosion structures and/or

   b. Importing sand of similar types from offshore sources.

4. Restrict the taking of sand by individuals in sensitive ecological and high use areas.

5. Prohibit the use of motorized off-road vehicles within the shoreline setback area.

Policy E

Promote an erosion-control structure limitation strategy.

Implementing Actions:

OSP, in cooperation with DLNR, DOT and the Counties, should:

1. Identify for management purposes, districts designated as hazard, chronic erosion, unstable beach, accreting beach, and stable beach areas.

2. Establish "Special Improvement Districts" for the development of uniform (standardized and aligned) erosion structures for hazard, chronic erosion, and unstable beaches.

3. Establish a cooperative program with County and Federal authorities to restrict new physical erosion structures except in designated hazard areas.

4. With County lead agency cooperation, have all illegal erosion control structures modified to meet requirements or removed.

5. Develop a management policy regarding offshore structures such as sand grabbers and artificial reefs.

Policy F

Develop an active public participation and education program to preserve and protect beaches.

Implementing Actions:

OSP should:

1. Establish an advisory committee of public interest groups, public and private school and university educators, and nonprofit agencies to help guide the education program.

2. Establish a public education program on beach and erosion processes and issues including:

a. Flood and erosion hazard television spots and brochures;

b. District and neighborhood "Adopt-a-Beach" programs and activities.

3. Establish a public participation program for input into erosion and beach programs planning through:

a. Statewide participatory planning debates on specific issues via newspapers, television, and radio shows;

b. Statewide public long-range planning workshops.

Policy G

Expand open space and shoreline setbacks.

Implementing Actions:

OSP, in cooperation with DLNR and the Counties, should:

1. Explore and evaluate options for expanding the shoreline setback in agricultural, rural, and conservation lands for open space purposes.

2. Explore and evaluate options for establishing an expanded variable setback based on annual erosion rates, coastal characteristics, and potential sea-level rise.

3. Seek legislative funding for strategic land acquisitions along the coastline where world-class resources exist.

4. Develop a disaster plan (and necessary legislation) which would call for acquisition of shoreline properties where improvements are destroyed by hurricane or tsunami.

5. Work with the Counties to limit through regulation (or legislation, if necessary) shoreline subdivision activity.

Policy H

Maintain and develop access to beaches and along the shoreline.

Implementing Actions:

OSP, in cooperation with DLNR, DOT and the Counties, should:

1. Establish a statewide policy requiring new erosion-control structures (where possible) to provide means of lateral shoreline access (e.g., steps, walkways).

2. Encourage through beach replenishment, sand production, and structure abatement, natural means of lateral access to the shoreline.

Policy I

Assure adequate funding resources and personnel.

Implementing Actions:

OSP, in cooperation with DLNR and DOT, should:

1. Seek increased legislative funding for line management functions.

2. Seek funding specifically for shoreline erosion and beach management, especially for enforcement.

3. Seek legislation which would establish an account separate from the State General Fund for fines and penalties which could then be used by the enforcement agency.

4. Seek continued Federal funding for coastline research.

5. Enroll in the FEMA (Federal Emergency Management Agency) Flood Insurance relocation option program authorized by the Upton-Jones amendment or otherwise develop incentives to relocate structures inland of chronic erosion zones.

6. Explore a range of other funding avenues including:

a. Beach maintenance taxes;

b. Impact fees;

c. County and State cost-sharing;

d. Park user fees.

Policy J

Plan for climate change, sea-level rise, and emerging issues.

Implementing Actions:

OSP should:

1. Identify agency personnel to monitor and track the scientific research on global climate change and sea-level rise and emerging issues.

2. Engage in long-term planning exercises — with senior planners, planning staff, and scientific experts — which take into account a range of possible geological and climatic changes.

3. Involve the public in educational and participatory planning activities which explore the consequences of climate change and sea-level rise.

NOTES

1. Coral reefs play a major role in the Hawaiian beach system (except, generally, the island of Hawaii) as a buffer for wave energy and as a source of beach material. Fringing reefs are most common around the older Islands — the Island of Hawaii has a much younger reef system. The only barrier reef in Hawaii is at Kaneohe Bay on Oahu (Noda and DHM 1989, 1-5).

Coral reefs are composed of the skeletons of corals and coralline algae. Shells and other materials become cemented into these structures to form a conglomerate reef (Moberly and Chamberlain 1964; COE 1979, 2). The more shallow and flatter reefs usually are found on the leeward and protected coasts.

2. The two major movements of sand are longshore transport and onshore-offshore exchanges. Waves striking the coastline at an angle move material both by the skewed up-rush and backwash of waves and by longshore currents generated by this wave energy (Moberly and Chamberlain 1964; COE 1979). Long shore transport is confined to the narrow area between the breakers and the limit of wave up-wash. Onshore-offshore exchange occurs between the shore and the complex network of channels, ridges and pockets within and around the fringing reef. Steep, high energy waves tend to move material offshore over the reef; low, long-period waves tend to move material shoreward (Moberly and Chamberlain 1964; COE 1979). Offshore currents, called rip currents, occur when water piled up against the shoreline seeks to flow seaward. Some rip currents can reach velocities high enough to scour and transport bottom sediments (Noda and DHM 1989, 1-14).

3. The concept of a littoral sand budget can be used to quantify sand inputs, transport and loss (Moberly and Chamberlain 1964; Noda and HDM 1989). If the rates of input and loss are balanced over time, the area in question can be said to be "in equilibrium." When the dynamics of accretion are not in equilibrium with losses through erosion, then net erosion over the long term will occur. A littoral cell is the name applied to a section of coastline which is in equilibrium and where there is little if any exchange of nearshore sand with adjacent areas. Littoral cells commonly are found in stretches of coastline isolated by rocky promontories or deepwater channels.

4. Waves approach the Hawaiian Islands from all parts of the Pacific Ocean and from some parts of the Indian Ocean (COE 1979, 8). The waves reaching Hawaii, which tend to be seasonal in nature, are categorized in a few general types: the northeast tradewind waves, Kona storm waves, North Pacific swell, south swell, and tropical storm/hurricane waves (Moberly and Chamberlain 1964). Northeast tradewind waves are most common and prevail during summer months. These waves typically have periods of 5 to 12 seconds and heights of four to eight feet (Moberly and Chamberlain 1964; COE 1979). The south swell occurs during summer months and is generated by South Pacific and Indian Ocean storms as far as 5,000 miles away. These waves arrive in distinct wave groups typified by long, uniform crests. South swell waves commonly have periods of 14 to 18 seconds and heights as great as 15 feet (Moberly and Chamberlain 1964; USCOE 1979). Kona storm waves usually occur between November and April arriving from the south and southwest. These waves are driven by "Kona" winds which replace the prevailing northeast tradewinds; Kona winds can be strong when produced by local storm fronts and tropical storms. Kona storm waves usually have periods of six to ten seconds and heights of up to 15 feet. The North Pacific swell is famous as the source of the large surf that has popularized surfing spots such as Waimea Bay, Pipeline and Sunset Beach. These large waves are produced by storms in the Pacific 1,000 to 2,000 miles to the northeast of Hawaii and usually arrive between October and April. These waves typically have periods of 15 to 20 seconds and heights exceeding 20 feet (Moberly and Chamberlain 1964; COE 1979).

5. Tsunamis are seismic waves often generated in the Pacific "Ring of Fire" as well as within the Pacific basin. While tsunamis are not significant factors in overall erosion processes, they have large a potential to do short-term damage. Coastline damage includes erosion and scouring of shoreline and nearshore areas; movement of sand, basalt and reef material inland or out to sea; and, occasionally severe damage to structures.

6. Hurricanes in Hawaiian waters are rare, although several have come close to or passed over several of the Islands. Hurricanes Nina, in 1957, Dot in 1959, and Iwa in 1982, caused severe shore damages. For example, Hurricane Iwa removed three to five feet of sand from the reef fronting the Hawaiian Electric Company power plant on leeward Oahu and at least 11,000 cubic yards of sand was eroded from Kahe Beach (Noda and DHM 1989).

7. The Island of Hawaii has some special problems regarding erosion and inundation. Hawaii, for the most part, lacks a reef system to diffuse the energy of incoming waves and to moderate seasonal extremes. With most of the wave energy unbuffered, coastal bluffs are subject to being overtopped and wave wash-up distances can be considerable during seasonal stormy months.

8. Large waves breaking over a reef also can raise the water level — called "wave setup" when solely due to wave action. This condition also allows waves to strike the shore at greater heights and energy intensities (COE 1979). Storms can result in the build up of strong rip currents that can transport sand to such depths that it becomes irretrievable. However, storms break down rocks and coral reefs and can produce large quantities of sand to replace some lost to deep water sinks.

9. Black sand and green sand beaches are of volcanic glass and olivine origins, respectively. Black sand beaches are particularly vulnerable to erosion and short-lived if their source is limited or terminated. Hawaii's sands are lighter by weight and more quickly reduced in size by abrasion than the quartz and feldspar sands commonly found elsewhere in the world (COE 1979). According to one study, reduced production of calcareous sands may make beach sands darker in color (due to the greater proportion of detrital grains) and thus less desirable for recreation (Noda and DHM 1989).

10. Shorelines become "hardened" when the gradual construction of revetments and seawalls results in even greater erosion, which leads to further erosion-control structure construction and ultimately to a walled shoreline.

11. Decreases in precipitation, for example, could mean less weathering and erosion inland resulting in less detrital sand production. The other extreme, heavy precipitation, could mean greater inland erosion, and coupled with human developments (i.e., non-point source pollution from runoff) could mean heavier siltation of coral reefs.

12. While there is at present no evidence that global warming has affected regional climate, scientists have suggested that El Nino-Southern Oscillation (ENSO) events, which can influence weather patterns throughout the Pacific, might be altered. The areas directly affected by ENSO events (e.g., upwelling and ocean temperatures), may be expanded and/or shifted in location which could have an impact on currents, winds and waves throughout the region. Even small changes in the current and wind patterns impinging on Hawaii could alter erosion and accretion patterns.

13. Air and water temperature changes also could have an impact on the production of reef and terrestrial sand. On the positive side, warmer ocean waters might promote greater biological activity in reef areas resulting in greater sand production.

14. The specter of more frequent and perhaps more violent storms rank near the top — with sea-level rise — as the largest threats of global warming to the Hawaiian coastline. More violent storms are even more of a threat to human life and property than higher ocean levels. Combined with the effects of higher water levels, storm surges and run-up could reach much farther inland. Greater frequencies of major storms could also mean that recovery periods after storms rarely are completed.

15. The consensus among climate researchers is that the doubling of CO_2 and increases in other greenhouse gases will cause an increase in atmospheric temperature of around 2° Centigrade (3.6°F) by as early as 2030. This in turn is expected to raise the sea level (due to glacial melting and ocean thermal expansion) at least eight inches by 2030 and 24 inches by 2100 (IPCC 1990). These estimates, however, are considered by some to be conservative. Some modeling results indicate a "worst case" scenario sea-level rise of 11 feet by 2100. Even the "business-as-usual" scenario of eight inches by 2030 suggests over a foot of sea-level rise for the Island of Hawaii and slightly less for the older Islands in a little more than a generation.

At the same time that the oceans are rising, many places in the world (including much of Hawaii) are sinking. Due to the immense weight of the shield volcanos which comprise the Hawaiian Islands, the Islands are actually subsiding into the Earth's mantle. Honolulu is "sinking" (relative to mean sea level) at the rate of 1.5 mm a year while Hilo is sinking at a faster rate of 3.8 mm year. In other words, some sections of Hawaii's coastline already are experiencing a relative sea-level rise of 6 to 15 inches per century. It should be pointed out that due to active faulting and volcanic activity on the Island of Hawaii, parts of its southeast coast experience "slumping."

Slumping occasionally has lowered small stretches of the coastline as much as one to two feet at once. Rapid slumping of a portion of the south Kilauea flank from the Kapoho area southwest into Hawaii Volcanoes National Park resulted in a lowering of about 15.5 miles of coastline up to 11 feet (Kanuha 1990).

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WASTE MANAGEMENT

THE RESOURCE

To some extent, the ocean has the capacity to store, biodegrade, dilute or disperse various wastes without adverse impacts upon coastal communities and ocean resources. Treated municipal sewage effluent, oil, plastics, dredge spoils and radioactive wastes are types of wastes which have been or are being disposed of in the ocean surrounding Hawaii. The nearshore waters receive pollutants from point sources, such as sewage outfalls, and nonpoint sources, such as soil erosion and urban runoff. As Hawaii's population grows, the amount of waste produced increases. At the same time, the State's disposal capacity is decreasing — landfills are filling up and sewage treatment plants are reaching their design-capacity limits.

In general, waste management practices involve disposing wastes in a place so as to minimize harm to the environment and to human health, or, if possible, benefit the environment. Protecting the environmental quality of Hawaii's nearshore waters is essential to maintaining the economic health of the State and its standard of living. Tourism, ocean recreation, fisheries, aquaculture, ocean thermal energy conversion, and ocean research and development all depend on clear, pollution-free waters.

RESOURCE MANAGEMENT

Water Quality Standards

For all State waters, standards for water quality have been established by the Department of Health (DOH) under Chapter 11-54, Hawaii Administrative Rules (HAR). These are based on

the Federal Environmental Protection Agency's (EPA) water quality criteria promulgated under the Clean Water Act (CWA). State waters are classified as either marine or inland waters. These waters are further classified by their uses for the purposes of applying standards.

Marine waters are divided into Class AA and Class A waters. The objective of Class AA waters is to preserve them "in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions." The objective of Class A waters is to ensure that their use for recreational and aesthetic enjoyment is protected (Chapter 11-54-03, HAR). Marine bottom environments are divided into two classes.

Standards are established for numerous pollutants, as detailed in Chapter 11-54-04, HAR. There are basic water quality criteria applicable to all waters which cover floating debris, thermal pollution, turbidity and specific criteria for nearly 100 toxic substances. The standards also describe certain uses and specific criteria applicable to inland and marine waters.

DOH is responsible for monitoring and enforcing these regulations. A statewide monitoring program is carried out by DOH, with periodic samples taken at numerous stations throughout the State with continuous data analysis. For recreation areas with intensive use, the water is sampled weekly. For all other areas, sampling is done on a monthly, semi-annual or annual basis, depending on the amount of recreational use and contribution of pollution sources. These samples are analyzed at the DOH laboratory on Oahu, and at support labs on each Island. The lab receives no direct Federal funds, but it receives indirect funds through Federal support for monitoring programs.

For all point sources of pollution, a discharge permit is required from DOH. These include, among others, wastewater treatment facilities, electric generating facilities, industries and agricultural facilities. These National Pollution Discharge Elimination System permits are required under the CWA. This EPA pollution-control program is administered in the State by DOH. For the discharge permit, there are conditions concerning monitoring requirements and submission of data to DOH on a periodic basis. Permits are classified as either major or minor, depending on the size of the facility and nature of the discharge. There are also continuous or intermittent flow permits, depending on the frequency of discharge. DOH requires dischargers to monitor themselves and submit results on a regular basis. Once a year, DOH conducts site inspections to assure sampling techniques and obtains "split samples" to determine analytical accurateness.

There are specific management practices for certain types of wastes, such as effluent from wastewater treatment plants, oil, plastics, hazardous wastes, radioactive wastes, dredge material and nonpoint source pollution. The significance of and management system for each type of waste are described below.

Wastewater Treatment

Most effluent from sewage treatment facilities in Hawaii is treated and discharged into the ocean. Of increasing concern to residents is the daily discharge of municipal sewage treatment wastes into the marine environment. With a growing population, the volume of wastewater will only continue to grow. The capability of existing treatment facilities to handle this increasing volume of wastes is an important consideration.

There are 11 major wastewater treatment facilities discharging 143.32 million gallons of treated effluent into the ocean per day. As with any point source of discharge, a National Pollution Discharge Elimination System (NPDES) discharge permit is required from DOH. There are a total of 15 wastewater facilities with NPDES permits. Four normally do not discharge into the sea. They use injection wells or reuse the effluent by watering cane fields or golf courses. The Counties manage municipal wastewater treatment facilities. Some private developers of resorts or housing projects are required to build their own sewage treatment facilities, which must meet the same NPDES regulations as municipalities.

The impact of sewage effluent on the marine environment depends on its content and on the rate, location, depth and quantity of discharge. Most effluent discharges have low levels of dissolved solids, very low levels of suspended solids and high nutrient values. Pathogenic bacteria and viruses also may be present. If an outfall is properly located, high initial dilutions and strong currents will cause immediate dispersion, so that accumulation of sediment on the ocean bottom is negligible. As long as they are located in deep water and are designed to withstand storm surge and tsunami events, deep ocean outfalls are not known to cause serious environmental problems.

Individual wastewater treatment systems, such as cesspools and septic tanks, are regulated by DOH. Cesspools that are constructed in permeable solid or rock formations may leach nutrients and bacteria into the groundwater and nearshore environment. In order to address this potential problem, the DOH director has stated a goal of banning all cesspools by 1991. To make this transition, DOH is promulgating amendments to Chapter 11-62, HAR, on wastewater systems. These amendments will severely restrict the areas where cesspools will be allowed. County Wastewater Advisory Committees formed on each Island selected those areas in which cesspools should not be allowed. These areas are called the proposed Critical Wastewater Disposal Areas. Throughout the State, this includes all areas within the 100-year flood range and groundwater recharge areas, where defined. Each County has recommended additional areas requiring protection.

Spills of Oil and Other Hazardous Materials

Petroleum supplied over 91 percent of the State's primary energy needs in 1988. All of it was shipped into the State. There are two oil refineries in the State, both on Oahu. To supply them at full capacity, approximately ten tanker deliveries are needed every month. The tankers load and unload at mooring

buoys situated off Barbers Point. The closest of these facilities is only 1.5 miles offshore. The loading cycle may take as long as two days to complete.

About 60 percent of the crude oil unloaded in Hawaii originates in Alaska. Tankers usually approach Barbers Point via the Kauai channel. Kaiwi Channel is used on occasion by vessels coming from Alaska, but the channel is more often the approach of choice for vessels coming from the West Coast. This approach puts the entire south shore of Oahu at risk from crude oil spills. Tankers call at the other Islands as well. These ships are usually product tankers, delivering fuel oil, motor gasoline or jet fuel. Just under half the products delivered are light distillates; over half are heavy oils. In the case of Maui, tankers approach from the north, and moor to the north of Kahului. This puts not only the north shore of Maui at risk from spills, but also Molokai, Lanai and Oahu, as winds and currents would move a spill west and south.

Petroleum and petroleum products released into marine environments are responsible for the deaths of organisms through coating and asphyxiation, contact poisoning, exposure to water-soluble toxic compounds and destruction of sensitive juvenile life forms. Oil also can generate indirect or long-term effects, such as the destruction of food sources for higher trophic level species. Ingestion and incorporation of sublethal amounts of oil and oil products into body tissues can result in infection, reduced resistance and other stresses. Chronic low-level concentrations in the water may interrupt normal physiological and behavioral responses, thus affecting survival.

Severe environmental impacts would result from accidental spills associated with the ocean transport of hazardous materials. For most hazardous materials, a significant spill in almost any location would result in the loss of a large proportion of the marine life in the immediate area. Chronic effects would be widespread and long-lasting, particularly for toxic and persistent chlorinated hydrocarbons, which are among the most likely candidates for ocean incineration. There is general consensus that under most circumstances, spilled material would be impractical or impossible to clean up.

Oil and chemical spills in the marine and coastal environments, the loci of Hawaii's tourism, could have major impacts on the State's economy. An uncontained oil spill at Barber's Point could impact the southern coast of Oahu, including the Nimitz Beach, Ewa Beach, Sand Island, Honolulu and Waikiki areas. Poorly handled spill incidences, whether or not they ultimately impact the natural environments, can lead to public or visitor misperception about the quality of these environments. Such misperceptions could compromise the tourism industry.

Handling of oil and hazardous materials at harbors increases the likelihood of an accidental spill in and contamination of these areas. However, accidents occurring outside harbor areas, although less frequent, can cause greater damage. Oil slicks, for example, can sometimes stretch for hundreds of miles.

In the event of an oil or chemical spill, both Federal and State agencies respond. Under Chapter 342D-50, Hawaii Revised Statutes (HRS), DOH monitors State waters for water-pollution violations. They may cite, fine and suspend operations of projects or activities in violation of Federal or State water-quality standards. Under Chapter 342D-51, HRS, responsible parties must report all discharges of oil, petroleum products and other hazardous substances within 24 hours of a spill. Failure to report or to initiate corrective action can result in a fine of $10,000 per day. DOH also may evaluate adequacy of corrective responses and prescribe additional actions. During oil spills, DOH, Office of Hazard Evaluation and Emergency Response (HEER), serves as the State on-scene coordinator to the U.S. Coast Guard. Chapter 342D-52, HRS, grants DOH authority to test water quality and effects on aquatic and other life after a spill. In the face of sufficient hazards, it may close beaches, suspend fishing and issue public health warnings about the hazards of consuming polluted fish and other marine life.

The State's Environmental Response Law, recently signed into law, gives DOH additional powers concerning oil and chemical spill clean-up. Administrative rules will be developed over the next year to clarify these powers and responsibilities. HEER is heavily dependent on Federal funds for its operation.

The Department of Transportation (DOT), Harbors Division, also is authorized to regulate and control polluting discharges in State waters. Chapter 266-3, HRS, specifically authorizes DOT to promote regulations necessary "to prevent the escape of fuel or other oils onto the harbors, ocean waters, and streams, either from any vessel or from pipes or storage tanks upon the land."

The Coast Guard is the primary Federal agency involved in the management of spills of oil and hazardous materials. Under the CWA, a national contingency plan was developed which provided for a national response team and center, and 13 regional response teams, which, in turn, develop regional and Federal local contingency plans. The Federal local contingency plan is developed by the "federal on-scene coordinator" in consultation with the regional team. The plan identifies: 1) probable locations of discharges or releases; 2) available resources; 3) disposal methods and facilities consistent with State and local plans; and 4) a local structure for responding to discharges or releases.

The Coast Guard provides on-scene coordinators for coastal zone spills, while the Environmental Protection Agency (EPA) provides them for inland spills. The boundary definitions for "coastal" and "inland" are designated in the regional plans by agreement between the two agencies. With very few exceptions, the owners and operators of vessels that discharge oil in violation of the Clean Water Act are liable for removal costs up to a statutorily established ceiling. The Petroleum Industry Response Organization is the oil industry's national coordinating body for oil spill management. The local industry cooperative is the Clean Islands Council. These organizations assist the responsible parties and coordinate with Federal coordinators.

Federal on-scene coordinators monitor removal and clean-up operations to ensure that they are conducted properly. When the polluter is unknown, not acting responsibly or the clean-up effort is insufficient, the on-scene coordinator may exert partial or total control of spill response. The Coast Guard can direct the mobilization of oil-spill control equipment within the State and request additional equipment from the Mainland. "Federalizing" a spill activates a Federal clean-up fund, which supports whatever actions are required to ensure proper clean-up.

In this area of the Pacific, Hawaii is a member of a regional response team made up of representatives from 13 Federal agencies and governments of Guam, American Samoa and the Commonwealth of the Northern Mariana Islands. This response team is co-chaired by EPA and the Coast Guard. In addition, the Federal government will establish a regional strike team within the State, associated with the Coast Guard.

Plastics

Plastics have become an integral part of the world economy. They are used for packaging, containers, household goods, furnishings, equipment and machines. However, the characteristics which make plastics so durable and convenient for use also make them nonbiodegradable and hazardous to the environment. When discharged, lost or abandoned in the marine environment, plastic debris can generate serious problems.

Entanglement of marine animals in six-pack rings, plastic strapping bands and fishing gear is one problem associated with plastic debris. The term "ghost fishing" has been coined to describe the death caused by lost or discarded fishing gear that continues to trap marine life. Ingestion of plastics and styrofoam also can adversely impact marine species. Human safety can be threatened if divers become entangled in fishing lines and nets. Plastic items, including synthetic ropes and netting, can also interfere with vessel operation, fouling propellers and clogging cooling-water intake systems. The disposal of large amounts of debris has the potential to adversely impact the aesthetic quality of beach areas.

Accidental disposal of plastic items at sea and littering from land account for some of the debris, but deliberate disposal is a much larger problem. Major sources of marine plastics pollution include commercial fishing vessels, merchant ships, U.S. naval and research vessels, passenger vessels and privately owned recreational vessels.

National legislation was recently enacted to adopt Annex V of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution by Ships, 1973 (MARPOL 73/78). Under this law, no plastics can be dumped at sea. As a result, the Coast Guard has adopted regulations designed to reduce the incidence of discharges of plastics and other ship-generated garbage into the marine environment. The Department of Land and Natural Resources (DLNR) and DOT, as well as numerous public and private institutions — including the University of Hawaii Sea Grant and Sea Life Park — are educating the public about regulations prohibiting marine disposal of plastics and their effects on the marine environment.

Hazardous Wastes

There are many types of hazardous waste. Some come from households, others from industry. Household hazardous wastes include insecticides, paints, cleaning agents and acids. There have been a few state-sponsored collection programs for household hazardous wastes in the past. A three-month program in 1989 consisted of a one-day pick-up on the Neighbor Islands and a two-day pickup period on Oahu. There is no collection program currently planned due to lack of State funds. Hence, household hazardous wastes often are discarded and sent to landfills. This unregulated disposal can lead to groundwater contamination. DOH has begun efforts to establish a permanent household hazardous waste collection system in Hawaii.

Industrial hazardous wastes — such as paints, hydraulic fluid and solvents — also are produced in Hawaii. Some data are available on the amount of hazardous wastes produced and stored on the numerous military installations around the Islands. There are a few private operations that recycle solvents, but most of Hawaii's industrial hazardous wastes are exported to the Mainland for disposal.

Management of all industrial hazardous wastes is done by EPA and DOH under the Resources Conservation and Recovery Act (40 CFR 260-270). EPA has primary responsibility for issuing hazardous waste permits, while DOH helps EPA inspect operations involving hazardous materials. DOH will submit an application to EPA requesting authorization as the primary hazardous waste management authority in the State. The State also is drafting its own hazardous waste regulations.

A registration system exists to regulate the transport of hazardous wastes. EPA gives identification numbers to the shippers, who must comply with specific Federal and State rules. DOH has not yet imposed hazardous waste transportation regulations.

Radioactive Wastes

Low-level wastes (LLW) are generated in all activities involving radioactive isotopes. LLW constitute the bulk of all nuclear wastes generated, including contaminated clothing, equipment and other medical and research nuclear waste products. Between 1957 and 1968, solid radioactive wastes were disposed of in Hawaii's waters by the U.S. Navy and University of Hawaii. In addition, liquid waste, resulting from maintenance and repair of submarines and ships, was discharged into Pearl Harbor until 1973. LLW must now be transported to Mainland sites for burial (DBED 1990).

In the future, Hawaii may be required to dispose of its own LLW. Mainland states currently providing this service may be closing their doors to wastes from other states, in order to accommodate their own waste disposal needs. The U.S. Department of Energy (DOE), in cooperation with relevant state agencies, is responsible for managing LLW.

High-level wastes (HLW) are generated in the processing of spent fuel from nuclear power plants or nuclear submarine and ship reactors. Currently, HLW generated in Hawaii (virtually all by the military) are transported to the Mainland for disposal. DOE also monitors civilian HLW: however, Hawaii has no nuclear reactor sites, which serve as storage sites elsewhere. Military HLW is stored in various DOE reservations throughout the country.

An issue relevant to Hawaii is the proposal for subseabed disposal of HLW. The difficulty in locating and managing safe land-based storage sites spurred an examination of at-sea and seabed disposal of HLW. Subseabed disposal would involve placing HLW into canisters, which would be imbedded into the sediment of the deep mid-ocean abyssal plains. This sediment has physical and chemical properties that help to isolate highly radioactive wastes from ocean waters. The U.S. Subseabed Disposal Program, administered by DOE, was established to assess the feasibility of using subseabed disposal methods for high-level nuclear wastes. More than 200 holes have been tested in the Pacific basin about 2,500 miles northwest of Hawaii (DBED 1990). However, funding for this program has been decreased substantially in recent years due to conflicts with international law, international political opposition to the proposal and serious environmental concerns.

The effect of radionuclides on the marine environment is dependent on a number of factors, including the physical state of the discharged waste, the method of waste discharge, wind and wave action, and other oceanographic and biological processes. Due to the many factors involved, the nature and levels of impacts these materials may have are difficult to estimate. Contamination of seafoods and impacts to marine ecosystems are of particular concern.

Dredge Materials

Hawaii's economic health, viability and the safety of its people are dependent upon shipping, which emphasizes the importance of maintaining Hawaii's harbors. Similarly, maintenance of flood control channels is required for the protection and safety of human life and property. Hence, periodic maintenance dredging is necessary to maintain operating depths in harbors and navigation channels, and to maintain flood protection capacity in flood control channels.

Dredge materials are composed of terrestrial silts and clays, mixed with sand, basalt or coral cobbles. Contaminants from urban, commercial and industrial areas surrounding harbors and flood control channels may be washed or discharged into these water bodies, where the contaminants may bind to the silts and clays. Consequently, the public is concerned about the probable impacts of dredging and dredge-material disposal activities on marine life. The impacts may result from smothering, settling of resuspended dredge sediments, potential toxicity and bioaccumulation of contaminants in dredge materials, and potential release of contaminants into the water column.

Dredging activities and their impacts on navigation and the environment are regulated by the U.S. Army Corps of Engineers (COE) under Section 10 of the Rivers and Harbors Act of 1899 (dredging) and by EPA and COE under Section 404 (discharge of dredge materials) of the Clean Water Act (CWA) and Section 103 (ocean disposal of dredge materials) of the Marine Protection, Research and Sanctuaries Act (MPRSA). Under Section 103, MPRSA, EPA has designated several dredge-material ocean dump sites in Hawaii. These sites are located off Nawiliwili, Kauai, about 3.3 nautical miles (nm) at 1,120 meters (m) depth; off Port Allen, Kauai, about 3.2 nm at 1,610 m depth; off south Oahu, about 3.3 nm at 475 m depth; off Kahului, Maui, about 5 nm at 365 m depth; and off Hilo, Hawaii, about 4 nm at 340 m depth (Arakaki 1990). COE records indicate that more than nine million cubic yards of dredge materials have been dumped at the South Oahu Dump Site since the 1960s, in conformance with Federal testing requirements.

Under the MPRSA, commonly known as the Ocean Dumping Act, EPA designated ocean dump sites and, in cooperation with COE, established test procedures to determine the acceptability of dredge materials for ocean dumping. COE implements dredge-materials testing requirements, determines the acceptability of dredge materials for ocean disposal and issues permits to transport dredge materials for ocean dumping after consideration of EPA opinions. EPA, which oversees the program, may find materials unacceptable for ocean disposal. COE may request an economic waiver in response to EPA objections. In Hawaii, COE does not require permit applicants to obtain a Water Quality Certification (Section 401, CWA) for the ocean disposal of dredge materials, because Section 103, MPRSA, does not require permit applicants to acquire such certification. Furthermore, the designated ocean disposal sites are located outside State waters (beyond the three-mile limit, the demarcation of State jurisdiction for these purposes).

The resuspension of dredge materials and probable impact of the resuspended materials on marine life and water quality currently cannot be judged as a significant public concern. Most maintenance activities are located within previously disturbed and developed areas, where marine life abundance and productivity are sharply depressed in comparison to predevelopment conditions. In contrast to daily resuspension of bottom sediments by ship traffic and frequent occurrence of storm runoff, maintenance dredging is a single, short-term (five to ten days), highly localized occurrence that happens on a frequency of once in five to ten years (less frequently for flood control channels). Based on DOE and EPA research on the environmental effects of dredging, resuspension of dredge materials does not result in any immediate or long-term degradation of water quality, except in very unusual circumstances such as the presence of significant concentrations of water-soluble contaminants from industrial sources being discharged into a waterway (Arakaki 1990). Based on, and within the limitations of, bioassay and bioaccumulation tests to date, dredge materials dumped at ocean disposal dump sites were not found to have toxic or unacceptable bioaccumulation effects on test organisms. Because ocean disposal sites are located far offshore, removed from human activities, no significant adverse effect on nearshore fisheries, water supplies, recreation, human health, safety or welfare are expected.

DOH surveys have found traces of contaminants in edible marine life found in Hawaiian harbors and flood control channels, as a result of contaminant discharges into these water bodies and runoff from commercial and industrial upland areas. These findings attest to the need to regulate and control contaminant sources, both point and nonpoint, rather than focusing on the symptoms (e.g., contaminated dredge materials). Contaminated dredge materials only can result from the introduction of contaminants into harbors and flood control channels by point and nonpoint sources. Regulating contaminant sources should, in turn, reduce contaminant levels in marine organisms caught for human consumption in harbors and flood control channels.

Nonpoint Source Pollution

Pollution can reach the marine environment from a variety of nonpoint sources. Sedimentation from soil erosion causes significant siltation problems for the nearshore environment. Sources include agricultural and urban storm water runoff. The use of agricultural chemicals in the State may contribute to the increase in residues found in runoff entering the nearshore waters. In rural areas, waste runoff from poultry, cattle and pig farms also enters the nearshore waters, increasing nutrient levels.

Golf courses are a common use of coastal land. Fertilizers and pesticides applied to these golf courses may find their way into coastal waters, potentially affecting water quality. The cumulative effects of these agrochemicals are difficult to assess. Golf courses also can contribute to sedimentation during the construction stage, if not adequately managed.

In many areas, storm water runoff into drainage ditches, canals and streams carries significant amounts of pollutants into nearshore waters, including pesticide and fertilizer runoff from yards, and petrochemical and heavy metal runoff from industrial parks and roads. Little effort is being made to intercept the contaminants in these streams; consequently, they end up in the nearshore water.

There are efforts to collect oily wastewater from service stations, car washes and maintenance shops. This wastewater contains oil, brake fluid, solvents, anti-freeze, grit, metal particles, fuel and other contaminants. Though such wastewater is pumped out frequently, its collection, transport and disposal is not monitored by the State. Some of this wastewater can conceivably end up back in storm drains.

DOH has prepared an assessment report and management plan on Hawaii's nonpoint source pollution (DOH 1989a; 1989b). The assessment report outlines the State's nonpoint source pollution problems. Sedimentation has been identified in the report as the primary nonpoint source pollution problem in the State. The management plan discusses those tasks which will be part of the Nonpoint Source (NPS) Pollution Control Program. As part of its first phase, the NPS Program is evaluating County grading ordinance effectiveness in controlling sedimentation. The program also is initiating public information and educational campaigns, including a public volunteer water-quality monitoring effort. The current NPS Program is dependent on Federal operational funds from EPA, which will be phased out in 1991. DOH will submit funding proposals to the 1991 Legislature in order to obtain permanent State funding for the program. Without such funding, it is conceivable that the NPS program will cease to exist.

MANAGEMENT ISSUES

Potential Social and Environmental Risks

Primary Wastewater Treatment

The question of whether secondary treatment of municipal wastewater is necessary has been hotly debated in Hawaii. The City and County of Honolulu has sought a waiver from the EPA requirement for secondary treatment of sewage by virtue of its deep ocean wastewater outfalls. Unlike continental areas, areas off of the Hawaiian Islands slope rapidly into deep ocean, where currents can actively dilute and disperse effluent. As a result, some believe that secondary treatment in Hawaii does not markedly improve water quality or reduce environmental impacts. Others speculate that the discharge of dissolved nutrients associated with secondary treatment may have even more serious environmental consequences than discharges of primary-treated wastewater.

In general, secondary treatment removes dissolved and colloidal organics by using microorganisms, which assimilate them. In the ocean, there are microorganisms that accomplish the same function. With good dilution and dispersion, and an almost unlimited supply of dissolved oxygen, no problems should occur. This concern is primarily a problem of social and political perception, rather than of technical feasibility.

Municipal Waste Incineration

The city's HPOWER plant at Barber's Point is designed to burn municipal solid waste. The environmental and human health effects of the plant emissions and ash disposal are community concerns. There also is disagreement over the completeness of combustion and the effectiveness of emission control at the plant. At this time, there is no plan for at-sea incineration of solid wastes.

Hazardous Waste Incineration

Hazardous waste incineration is very controversial. Ten to twenty percent of all hazardous wastes are amenable to incineration (DBED 1990). Although they comprise a relatively small portion of all hazardous wastes, they are among the most toxic. Because of their characteristics — such as their organic, chemical and energy content — they remain potentially hazardous for long periods of time. Other methods of storage and disposal are not effective management alternatives. Incineration can reduce the volume of hazardous waste by more than 99 percent (DBED 1990). However, many incinerable hazardous wastes contain high amounts of organically bound chlo-

ride, which generates highly corrosive and toxic hydrogen chloride gas when burned. The formation and release of products of incomplete combustion during incineration also may pose a significant risk to the public. Human health risks from incineration of carcinogenic heavy metals, such as chromium, cadmium and beryllium, can be significant. Potentially hazardous ash also is produced. The disposal of this ash is an important issue.

Land-based facilities are required to have air pollution control equipment, such as scrubbers, capable of removing acid gases from the smoke. However, these toxic emissions are then disposed of either in ponds, in the case of scrubber water, or landfills, in the case of solid filters. A private company may propose a hazardous waste incinerator for Oahu's Campbell Industrial Park. This site is being considered with the intention that this facility's smokestack emissions would be dispersed in the waters off Barbers Point by the tradewinds.

The incineration of liquid hazardous wastes at sea also has been proposed. However, the use of scrubbers on ocean incinerator vessels is not easily feasible because of the unstable platform. Some argue that scrubbers are not entirely necessary because of the seawater's natural capacity to neutralize hydrogen chloride gas, and because the vessels operate far from human populations. At this time, ocean incineration has not been approved by the EPA as an appropriate method of waste disposal. There is considerable public opposition because of the significant contamination of the surface ocean layers by the emissions, and the danger of catastrophic spills.

Maintenance of Existing Facilities

Problems have occurred at some sewage treatment facilities in the State as a result of equipment failures. In these cases, sewage was released in a less-treated form. The effluent quality was lower than allowed by NPDES permits and the plant managers, either the Counties or private developers, were fined for discharge violations. In some cases, plant operators have received repeated citations for violations. These violations point to the need to improve the maintenance of sewage treatment facilities. Many existing facilities are being used beyond their design capacity limits. This indicates an entirely different problem.

Support for Treatment Facility Operators

Control technology for wastewater treatment is becoming more sophisticated. More effective and efficient performance is expected from these technologies. As a result, more training opportunities and career advancement incentives are needed for treatment facility operators.

Facilities and Infrastructure for Municipal Wastewater Treatment

When existing wastewater treatment facilities were built, they were designed to handle waste volumes from the community for 20 years. Less than 20 years later, many of these treatment facilities are now being operated close to their design capacity. The question is whether to build additions to these facilities, or stop growth in the housing developments that connect to them. Unfortunately, the planning for housing developments is not well coordinated with planning for infrastructure development, resulting in overworked treatment facilities.

Collection System for Household Hazardous Wastes

There is no program for the collection and disposal of household hazardous wastes in the State. Thus, household hazardous wastes are dumped at landfills. This can pose a potential contamination threat to groundwater.

Funding

Hazardous Waste Management Program

The DOH Hazardous Waste Section is developing its capability to manage the State's hazardous waste stream. It soon will request authorization from EPA to permit hazardous waste transfer and disposal facilities. However, this effort is being hampered by lack of funds and limited personnel (four inspectors, one permit person, one planner, and a part-time manager). Consequently, DOH lacks adequate enforcement capabilities.

The establishment of HEER is an important first step for the State to deal with the problems of hazardous waste and oil spills. However, it also is significantly underfunded and understaffed. There are seven staff members — three of whom are on loan from EPA — and two clerical workers. Federal funding and "loaned" personnel are intended only to assist the State with the planning phase of its program and provide some emergency response clean-up assistance. These funds, which are provided through an EPA Superfund core grant, are to be phased out within two or three years. To date, the State has not supplied adequate funding for the program to stand on its own.

Nonpoint Source Pollution Program

The State's Nonpoint Source Pollution Program is very new. Consequently, it is difficult to assess its success. However, it can be said that since there is virtually no State funding for the program and no full-time State employee working in it, there is an apparent deficiency in State financial commitment to this program. The two staff assigned to the program are on loan from Federal agencies, one from the Soil Conservation Service and one from EPA. The program has just recently hired five, temporary field technicians, who are responsible for evaluating the effectiveness of County grading ordinances.

Since it is just getting started, the program has not yet begun to deal with the other nonpoint source pollution problems, such as cesspool leaching, storm drains, golf course runoff and other forms of agrochemical pollution. It also is hampered by a lack of baseline data. Although a coastal water quality monitoring program exists, there is no such program to address nonpoint source pollution concerns.

Oil and Chemical Spill Response Capabilities

Oil and chemical spills are potentially catastrophic to the State's marine and coastal ecosystems and economy. Rapid and effective response to spills is essential. However, since the State depends heavily on the Coast Guard to respond to oil and chemical spills, the State's capability to assist in response efforts or handle spills independently is extremely limited. Hawaii has an oil spill contingency plan and response inventory, which the Coast Guard Marine Safety Office recently updated. It highlighted several inadequacies, some infrastructural and others institutional. Hawaii has too little equipment to respond to a major spill effectively. Furthermore, recent Coast Guard staff and budget cuts have resulted in limited planning and preparedness capabilities.

Comprehensiveness

Marine Plastic Pollution

Marine pollution from plastics is a significant problem that the State needs to address in a more comprehensive fashion. Educational efforts by DLNR, DOT and University of Hawaii Sea Grant are beginning to reach ocean users. However, many coastal recreation areas do not have any informational flyers or posters on the issue. In addition, these recreation facilities do not always have solid waste receptacles on site. Ocean recreation events, including fishing tournaments, do not regularly provide incentive programs for boaters to bring their garbage back to shore for proper disposal. Recycling programs for plastics are limited.

Water Quality Monitoring

Comprehensive statewide water quality monitoring programs are needed. The current State program is insufficient, especially in terms of sampling frequency and number of sampling sites. Three factors contribute to these deficiencies: 1) lack of funding to expand the program; 2) DOH water quality laboratory is operating at full capacity and having problems with lack of space and qualified personnel; and 3) DOH field personnel are also fully occupied. Current State efforts to control nonpoint source pollution are hampered by the lack of baseline data on water quality. Federal funds for water quality monitoring programs are dwindling.

Federal, State and private monitoring programs exist but are not coordinated. Existing data from these programs are not analyzed on a comprehensive or comparative basis to provide an overall water quality picture. Marine life monitoring is not required as a means to assess potential impacts of pollution on the marine environment. Standard quality assurance and quality control programs must be agreed upon and implemented by all monitoring programs.

Legal Authority

Hazardous Spills

In Hawaii's new Emergency Response Law, it is not clearly articulated that the DOH may act to protect natural resources from hazardous spills if there is no clear threat to human health or welfare. The rule-making procedure for enforcing the law offers the opportunity to clarify this shortcoming. Furthermore, in terms of administrative capability, DOH does not have sufficient trained personnel to assess the damage to natural resources resulting from a spill. It is also not clear whether HEER has the authority to hire staff on a contractual basis to provide this service.

Alternative Sewage Treatment Methods

A variety of alternative methods for treating human wastes — such as composting toilets and leaching systems using water hyacinths, sedges and lemongrass — are not approved by the State and Counties for residential use. Leaching systems require a large space and could be restricted to low-density residential developments if they are to be included in building codes.

Coordination

Hazardous Waste Management on Federal Installations

The Federal government is a major land owner in Hawaii. On some lands, there are facilities for aircraft and ships, and storage for munitions, fuels and chemicals. These installations are required to provide information on quantities and types of wastes on hand. These military wastes are subject to the same regulations as civilian hazardous wastes. Since there have been problems in other states with the management of hazardous wastes on Federal installations, it is important for Hawaii to ensure that these wastes are properly managed. Some information is available on the amounts of hazardous waste generated by Federal facilities. COE is well-funded to manage these hazardous wastes. The problem, however, lies in inadequate coordination between Federal and State management efforts.

Oil Spill Response

The recent update of the State's oil spill contingency plan pointed to several areas where improved coordination is needed. Currently, the on-scene coordinator has the responsibility to ensure adequate clean-up of a spill, yet incomplete authority to direct it. Granting greater authority to the on-scene coordinator would expedite decision-making, particularly if contingency plans incorporate preapproval for any actions requiring permits, such as for use of chemical dispersants.

Private clean-up organizations exist, such as the Clean Island Council and Petroleum Industry Response Organization; however, it is essential that their capabilities be effectively utilized in coordination with Federal and State efforts. The availability of emergency response equipment and personnel is limited. On some Islands, equipment and personnel are not available at all. If all agencies and organizations potentially involved in spill management would confer to predetermine an array of appropriate actions to take under particular circumstances, the on-scene coordinator could exert on-scene command without causing undue controversy. If effective, such a decision model might transfer usefully to other environmental disaster response plans.

Public Information and Involvement

When an Environmental Assessment (EA) is prepared for a proposed project, the State agency responsible for the area or resource determines whether the proposed activity has the potential to cause significant environmental impacts. If it is determined affirmatively, then an Environmental Impact Statement (EIS) is prepared. The public can comment on the EIS and thereby take part in ensuring its adequacy. However, when a "negative declaration" is made, stating that the project will have no significant environmental effects, the public has no means to comment on the decision. If individuals or groups disagree with the negative declaration, or feel the EA is inadequate, they must file a lawsuit.

Results from water quality monitoring programs are not readily available to the public in an understandable format that analyzes trends and current status of sites. Public understanding of oil spills and their potential impacts on the marine environment must be improved. The public is not actively involved in marine life monitoring programs and is not fully aware of any standard procedure for reporting spills.

Recycling, source reduction and anti-littering programs depend on public awareness and involvement for success. However, many of these programs do not receive adequate support from the State. The success of nonpoint source pollution control is especially dependent on public awareness and involvement since no Federal regulations exist, and controls are voluntary.

RECOMMENDATIONS

Objective

Ensure that the State is capable of effectively regulating waste disposal, and accidental oil and chemical spills, while protecting human health and minimizing environmental degradation.

Policy A

Minimize point and non-point source pollution and its accompanying impacts on the ocean and coastlines by developing appropriate regulatory controls, incentives, monitoring, and research programs.

Implementing Actions:

DOH should:

Water Quality

1. Monitor and provide input on proposed changes to Federal statutes and regulations regarding water quality and waste disposal.

2. Sponsor regional and State workshops to review existing DOH and other monitoring programs in order to establish a comprehensive water quality and marine life monitoring program for all coastal waters.

3. Fully implement the water quality monitoring program in the Clean Water Branch. This would require additional funding from the Legislature.

Municipal Sewage Treatment

4. Work with the Counties to upgrade sewage treatment facilities and build new facilities. This may require additional funding from the Legislature.

5. Convene a statewide policy and management workshop on the relative costs and benefits of primary and fertilizer.

6. Work with Counties to develop alternative funding mechanisms for constructing additional sewage treatment facilities as building development continues.

7. Increase training and career advancement incentives for treatment facilities operators.

8. Implement the revised Chapter 11-62 Hawaii Administrative Rules (HAR) which describes the boundaries of Critical Wastewater Discharge Areas on each island.

9. Encourage each County to maintain adequately trained environmental engineers to evaluate proposed individual wastewater treatment systems.

OSP should:

10. Work with the Counties to ensure that sewage treatment facilities have adequate capacities to handle incoming waste volumes in order to prevent discharges of untreated sewage into nearshore waters. This will require coordination of planning for housing development with planning for infrastructure development.

DOH should:

Individual Wastewater Treatment Systems

11. Work with the Counties to support the use of non-cesspool alternative methods of domestic sewage treatment. This would need to be accomplished through the implementation of wastewater rules which allow for these types of systems.

Municipal Solid Waste

12. Establish solid waste management standards that Counties would be expected to meet in developing their solid waste management plans, including site selection and closing criteria for landfills.

13. Ensure that municipal solid waste incineration - including smokestack emissions and ash disposal - is fully monitored and monitoring information is readily available to the public.

Hazardous Waste

14. Establish an effective monitoring program for all hazardous or toxic wastes. To do this the Legislature should increase funding and staffing for DOH programs.

[This would enable DOH to increase its monitoring of all hazardous waste treatment/storage/disposal centers and ensure proper treatment, storage and disposal of wastes.]

15. Work with industry to develop incentive programs to minimize hazardous or toxic wastes and to develop spill prevention, preparedness and response capabilities.

16. Develop an effective enforcement program for hazardous waste regulations.

17. In the event of hazardous waste incineration, ensure that plants - including smokestack emissions and ash disposal - are fully monitored and monitoring information is readily available to the public.

Radioactive Wastes

18. Establish a management program for overseeing the collection, transportation, disposal and monitoring of all radioactive wastes.

Non-point Source Pollution

19. Improve the effectiveness of the non-point source pollution control program. To do this, the Legislature should increase funding to DOH: to prioritize and address non-point source pollution issues; for State personnel for the program; and for research into the impacts of various land uses on nearshore habitats.

Litter Control

20. Establish a program to identify and regulate sources of unregulated waste disposal, including fishing gear, mass release of helium filled balloons, and onshore and offshore littering.

Policy B

Promote waste minimization through source reduction, recycling, and other alternative methods of waste management as part of the State's regulatory programs.

Implementing Actions:

DOH should:

Wastewater Treatment

1. Support water reclamation through a variety of methods, including artificial marshes, sedges, water hyacinths and other plants as means of absorbing nutrients contained in primary treatment effluent, in addition to the current practice of using this effluent in golf course irrigation.

2. Support the utilization of sewage sludge, after proper treatment, as composted fertilizer.

Municipal Solid Waste

3. Work with the Counties to establish redemption centers for recyclable materials, including plastic, paper, glass, aluminum, and used motor oil.

4. Work with the Counties to provide incentives for recycling and composting.

5. Coordinate regulatory controls and incentive programs to discourage illegal dumping of oil, sewage from vessels, plastics and other waste into ocean and coastal waters.

DOT should:

6. Provide incentive programs to encourage commercial and recreational vessels to bring plastic wastes and sewage back to port for proper disposal.

7. Require the establishment of facilities for sewage and used oil, along with receptacles for solid waste, separated into plastic, paper, aluminum, and glass, at all small boat harbors and boat ramps. At the same time, develop educational programs for boaters about the benefits of utilizing these facilities. [See Harbors section.]

DOH should:

Hazardous Waste

8. Support programs to reduce the production of hazardous wastes in the State's industries. Use waste audits to pinpoint the sources of hazardous waste in different industries. Offer incentives for industries to take preventive steps such as raw material substitution, process redesign, product redesign, *in situ* recycling, and enhanced containment during transfer and processing.

9. Establish a free and convenient collection system for household hazardous wastes, such as pesticides, paints, and solvents.

Policy C

Be prepared to respond effectively to spills and other discharges involving oil and other hazardous materials in the State's waters.

Implementing Actions:

DOH should:

1. Increase staffing for the department's Office of Hazard Evaluation and Emergency Response (HEER). This would require additional funding.

2. Arrange for HEER to contract services for natural resources damage assessment from spills.

3. Clearly articulate in the rule-making procedure for the State Emergency Response Law that the department has the authority and responsibility to respond to spills or releases that may harm natural areas without clear threat to human health. [These rules and responsibilities for protection of natural resources also need to be integrated with the existing authority of DLNR.]

4. Initiate a program to evaluate and take action on the hazardous waste problems in all Federal facilities in Hawaii in cooperation with the COE.

5. Identify those hazardous waste cleanup sites that should be included in the State and National Priority List for Superfund sites.

6. Conduct an economic impact assessment study to determine the impact of an oil spill in specific areas, such as Waikiki. This would help the State determine how much money it is willing to pay for prevention.

7. Conduct a study with Federal, State and County agencies, and petroleum shippers and refiners to approximate the probable risks of various categories of oil spills. This would require close and candid cooperation between industry representatives, the USCG and State representatives.

8. Review existing response plans and approved strategies for oil spill response. This should include an ongoing effort to monitor technical literature for innovations in coping with monitoring, containment, recovery and clean-up of oil spills.

9. Evaluate actual oil spill response capacity in the State or available to the State on short (12 hour) notice. Allocations to upgrade capacity in either State or Federal agencies, or in the private sector must be based on a realistic appraisal of what already exists, its suitability for Hawaii and the probabilities that it might be needed.

10. Work with Federal agencies to devise incentives for the oil industry to enhance the procedural safety of oil shipments, and to ensure immediate reporting not merely of spills, but of high-spill-risk situations.

11. Work with the U.S. Coast Guard to expedite the sampling process for identifying spill sources.

12. Establish a grievance mechanism to provide a forum for citizens to seek compensation when they are affected by spills.

Policy D

Enhance public awareness and participation with regard to sources and effects of marine pollution, as well as methods and programs for waste disposal and cleanup.

Implementing Actions:

DOH should:

1. Seek increased funding from the Legislature for its public education program to enhance public awareness of wastewater disposal facilities and environmental programs and the effects of marine pollution on the environment. Such programs should also encourage public participation in clean-up activities.

2. Increase support of community programs such as "Adopt-a-Beach" (e.g., trail, storm drain, etc.).

3. Make water quality monitoring information, which analyzes trends and identifies problem areas, readily available to the public in an easily understandable form.

4. Establish a toll-free number for citizens to report violations of waste disposal regulations.

5. Incorporate public comment into the preparation of long-term toxic waste clean-up plans.

Policy E

Ensure cooperation among regulatory and management agencies within the State, and among Federal, State, and County agencies.

Implementing Action:

DOH should:

Conduct a comprehensive review of waste management regulations, procedures, and programs at the County, State, and Federal levels to identify the gaps and overlaps as well as opportunities for improved cooperation and information-sharing among the agencies.

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AQUACULTURE

THE RESOURCE

Aquaculture is the farming of aquatic organisms on land or in the ocean, including fish, molluscs, crustaceans and aquatic plants in salt, brackish or fresh water. Although the Hawaii Ocean Resources Management Plan is primarily concerned with ocean-related impacts of aquaculture, it is important for a comprehensive management plan to view this sector in its totality. Information and issues concerning freshwater aquaculture are thus included in this technical paper.

Aquaculture is currently one of the fastest growing industries in Hawaii with an average annual growth rate in revenues of 13 percent and an estimated income of over $21 million in 1989 (DLNR 1989). Technical support and consulting services (the service sector) brought in the bulk of revenue for the industry with over $14 million in sales. In 1989, 22 Hawaii-based firms were involved in this sector, providing research, training, conference, education and consulting services. Product sales (the commercial production sector) are estimated to furnish another $7 million, primarily from the sale of freshwater prawns and marine shrimp. Although the commercial production sector currently represents half the dollar volume of the service sector, its importance should not be overlooked. It is estimated that aquaculture furnishes from two percent of the total fisheries production of the State. Because of the high value of its produce, aquaculture comprises 13 percent of the total value of all seafood produced commercially in Hawaii (DLNR 1990).

Although the present growth of aquaculture seems to indicate stability, in the recent past large scale private investment in the production sector and subsequent withdrawal of said investment, a serious disease epidemic in the marine shrimp production sector, and a lack of available seed stock in other sectors has shown aquaculture in Hawaii to be an economically cyclical, but growing, industry. In 1979, less than $2 million in production sales and no service sales were reported. While 1979 revenue was related primarily to a single species, freshwater prawns, the variety of aquacultured species has now expanded to over 35 different products including marine shrimp, Chinese catfish, tilapia, carp, rainbow trout, abalone, *nori, ogo, spirulina,* oysters, salmon and lobster. In addition

several species of ornamental aquatic plant and animal species are being cultured along with juvenile shrimp and prawns for stocking. Future species prospects include *mahimahi,* japanese flounder, baitfish, giant clams, limpets, pearl oysters and sea cucumbers. This infant industry could grow to play an important role in an economically diversified and more self-sufficient Hawaii and expand the State's export market as well (DLNR 1989; 1990).

Aquaculture resources are based largely on the technical support and food production sectors of the industry. Advances in marine biotechnology and research indicate that equally valuable returns may lie in new aquacultural areas such as marine industrial chemicals, marine pharmaceuticals and biomedical research models. In recent years, aquaculture researchers have begun to investigate the feasibility of mass aquaculture for a variety of invertebrate species. Marine biotechnology shows great potential for expanding the opportunities in commercial aquaculture (Main et al 1987). The aquacultural resources in Hawaii can be broken down into three main subgroups: environmental resources, cultural resources and current production facilities. Understanding each of these resource sectors is important in developing a comprehensive public policy and maintaining the viability of aquaculture in Hawaii.

Physical Environment

Hawaii's environmental resources have been a major factor in the growth of the aquaculture industry. Hawaii is the only state which has year-round temperatures suitable for growing tropical, sub-tropical and temperate aquatic species. Solar intensity in certain parts of Hawaii is among the highest in the world. The warm climate and solar intensity play a major role in minimizing the energy costs involved in temperature regulation. Hawaii also has some of the purest water in the world. One of Hawaii's leading aquacultural crops takes advantage of this situation in the raising of high quality, freshwater prawns (DLNR 1984).

The ocean surrounding Hawaii provides a virtually unlimited supply of relatively clean, free, salt water. Salt water (18,000+ ppm of chloride) and brackish water (250 - 18,000 ppm of chloride) also are available from various limestone and volcanic aquifers. Both brackish water and salt water are underutilized resources at this time. Emphasis on saltwater aquaculture development could relieve pressure on limited freshwater supplies while utilizing semi-neglected resources. As a byproduct of the Ocean Thermal Energy Conversion (OTEC) experiments on the Island of Hawaii, researchers have successfully used cold, nutrient rich, pathogen-free, deep sea water for aquaculture. OTEC could provide aquaculture with fresh water as well, although the relative cost may be detrimental (DLNR 1984; 1990; Fast and Tanoue 1988).

Hawaii has a large ocean and land base suitable and potentially available for aquaculture use. The aquaculture development report for the State (1978) identified 135,000 acres of primary lands and 500,000 acres of secondary lands suitable for aquacultural development. Primary lands are those lands outside of urban zoning districts and below 3,000 feet elevation that have less than a five percent slope, fresh, brackish or salt water potentially available, average air temperatures above 20 degrees centigrade and clay, loamy or clay-loam soil, which can be compacted into ponds. Secondary lands have the above characteristics but have less suitable soils. These include lava lands. Despite the large amount of potentially available acreage, zoning, land ownership, prior pesticide use, the proximity and availability of water resources and other factors greatly limit the actual availability of the land base. User conflicts and untested legal questions also may limit the availability of offshore aquaculture development.

Cultural Environment

The aquaculture industry in Hawaii is blessed by many unique cultural factors, both traditional and modern. The Hawaiian lifestyle has always relied upon ocean resources. Ancient Hawaiians made abundant use of the sea and utilized the ocean for their major source of protein. Although the introduction of cattle and other animals has reduced this reliance on marine produce, Hawaii is still the largest per capita seafood consumer in the United States. Much of this owes to the State's unique ethnic and cultural make-up. Over half of the population now comes from Pacific Island and Asian cultures in which seafood is a major dietary component.

The traditional/historical role of aquacultured seafood in ancient Hawaiian culture is a major factor, which should be considered a resource to the modern aquaculture industry. As early as 1901, observers noted that over 104 manmade fishponds actively were involved in the farming of marine species, including the fast-growing grey mullet or *ama,* milkfish or *awa,* and the *ahole* and *o'opu* (gobies). These ponds covered almost 3,000 acres and produced 680,000 pounds of fish annually. Although this seems substantial compared to Hawaii's modern aquaculture industry, it is estimated that there were more than 340 fishponds when aquaculture production was at its pre-European contact peak.

With the decline of the Hawaiian population following Western contact and the rise of a plantation economy, many of these fishponds fell into disrepair and disuse. Recent studies show that several of these ponds could be renewed for present-day aquacultural production. In a recent study, six of 67 ancient fishponds studied were found to have excellent potential for mullet and milkfish production, and 15 ponds were found to have good potential with minor repair or improvements (DPED 1977).

The rise of the plantation economy early in this century also marked an era of important reliance on agriculture. For decades, sugar and pineapple were major economic forces in the Islands. With the decline of these industries, water and land will become available for other uses. As a sub-industry of agriculture, aquaculture could use these resources while continuing the cultural connection to the land and diversified economy now associated with agriculture.

The aquaculture industry thus has a substantial advantage in that a cultural/historical base of familiarity and acceptance has already been laid both for the consumption and culturing of aquatic resources. The resurgence of aquaculture in Hawaii presents a viable means to produce traditionally accepted protein sources and an opportunity to connect that production to the reemergence of Hawaiian culture and community self-sufficiency. For the people who work on such projects, aquaculture is more than a commercial activity. It is a way of life that links traditional heritage to the modern world. Few other industries in Hawaii can make this claim.

Production Facilities

Aquaculture has played a significant role in bringing diversified investment to Hawaii. There are 50 seafood farms in operation, employing more than 500 people and growing 35 different species of aquatic resources in production facilities that range widely in technical sophistication and complexity. Most are on Oahu (DLNR 1988; 1989; 1990).

Small scale "cottage" farms are the dominant organizational form in Hawaii, accounting for 63 percent of total aquaculture production organizations. These farms are fairly stable (8.5 years of average operation), family-oriented businesses with one or two employees. Many of these families own their own land and are thus able to keep one of the primary operating expenses for aquaculture in Hawaii relatively low. These cottage farms account for much of the production of aquacultured species in Hawaii. Sixty-six percent of Hawaii's prawn production and all of its freshwater and ornamental fish production come from cottage farms (Main and Deupree 1986).

Ten percent of Hawaii's 50 aquaculture farms are incorporated. Due to the larger size of corporate operations, these operations accounted for about 70 percent of total dollar volume in the aquaculture production sector in 1989. In 1986, one-half of all shrimp and algae production facilities and one-third of the prawn farms in the State were corporate-owned. Small-business accounted for the other 50 percent of shrimp and algae farms (ibid).

Although the majority of aquaculture production in Hawaii is sold locally and directly by the producer, international companies from several continents are becoming an increasingly important part of the industry. International investment in the aquaculture industry includes investment from countries as diverse as Norway and Japan. Recent foreign investment in aquaculture production in Hawaii is estimated to be as much as $15 million, with millions more being brought into the State through international consulting by Hawaii-based firms (DLNR 1989).

Mainland companies also have found it advantageous to locate aquaculture facilities in Hawaii. One company, originally established in California, now raises abalone, oysters, sea urchins and salmon on the Kona Coast of Hawaii (*Islands*, March/April 1989, Santa Barbara, California). In 1989, this company continued its support of Hawaii aquaculture with a $20 million expansion program. Partial funding of this expansion program came from Japanese investment (ibid).

Another California-based company operates the largest shrimp farm in Hawaii, comprised of over 153 acres of aquaculture ponds. It has a well-known roadside stand, which offers freshly cultured shrimp and prawns to seafood-hungry residents and tourists alike. It also raises and sells several species of fish. The company recently opened a processing plant in the Mapunapuna area of Oahu (ibid).

Kahuku Aquacultural Park on Oahu is a privately owned and independently operated park with both fresh and saltwater aquaculture. Its six private farms, on land owned by Campbell Estate, are involved in shrimp and fish production (ibid).

Production from government-funded aquaculture facilities is usually a byproduct of research. There is commercial production from private firms operating in government-sponsored aquaculture parks, but production is not directly funded by the public sector. Natural Energy Laboratory Hawaii Authority (NELHA) aquacultural park is an example of this type of government facility, which encourages commercial production and provides research and technical support services to commercial producers (ibid).

The Anuenue Fisheries Research Center (AFRC) is an example of a government-owned production facility. AFRC, operated by the Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR), has a 1.6 hectare (ha) facility that conducts research and produces fresh and saltwater aquaculture species. It has been providing freshwater prawn seed stock to local aquaculturists for more than a decade. It is now conducting research into seaweed projects as well as larval culture of marine shrimp, mahimahi and crabs (Main et al 1987). Maui County also has supported the culturing of marine shrimp seed stock for commercial production support on Molokai (ibid).

Although there has been interest in government-supported aquaculture restoration and enhancement of depleted marine fisheries, only recreational freshwater stock enhancement (catfish and trout) is being undertaken at this time.

RESOURCE MANAGEMENT

A range of Federal, State and County regulatory regimes and agencies manage aquaculture activities in Hawaii. Access to water (fresh and salt), siting, species choice, system design, effluent discharge, financial aid, and research and extension services are overseen by different agencies operating on different governmental levels with different regulatory responsibilities and legislative mandates. These areas of responsibility fall into two main categories: regulation and support.

Federal, State and County regulatory and support regimes shape aquaculture in Hawaii. Attempts are being made to coordinate these diverse agencies and their programs as well as

to provide linkages between the various sectors of the aquaculture industry. In 1985, the Hawaii Aquaculture Advisory Council was authorized by the the State Legislature to promote communication between private industry and State government agencies. A Memorandum of Understanding formalized linkages between the University, State agencies and the Oceanic Institute. The Mariculture Research and Training Center, the State Aquaculture Development Program and the UH Sea Grant Extension Service jointly sponsor an annual series of workshops on topics pertinent to local aquaculturists (Main et al 1987).

Regulation

Federal Authority

The U.S. Army Corps of Engineers (COE) has jurisdiction over structures placed in waters from the shoreline seaward. COE generally requires a permit for projects involving dredging or filling-in navigable waters, stream diversion or impoundment and for projects affecting swamps, marshes and wetlands. Any individual who wants to do work "in, under, across, or on the banks of navigable waters" must first obtain a permit from COE. Its regulatory mandate stems from several laws including the Rivers and Harbors Act of 1899, Clean Water Act, National Marine Protection and Research Act, and the Coastal Zone Management Act of 1972. COE is responsible for an Environmental Assessment and if necessary an Environmental Impact Statement for projects with significant environmental impacts under the Environmental Policy Act of 1969. Permit issuance is generally undertaken after all State and County permits are granted.

Another Federal agency involved in Hawaii aquaculture is the Department of Interior, which interacts with local authorities on endangered species issues.

State Authority

On the State level, the Department of Health (DOH) is a primary regulatory agency. DOH is charged with enforcing the National Environmental Policy Act of 1969 and the Hawaii Environmental Impact Statement Law of 1974. The Environmental Assessment/Environmental Impact Statement requirements are triggered whenever public projects or coastal zone area projects requiring water or land-use permits are deemed to have significant environmental impact; defined as "the sum of those effects that affect the quality of the environment, including actions that irrevocably commit a natural resource, or adversely affect the economic or social welfare" (Chapter 343, Hawaii Revised Statutes [HRS]).

DOH also is the lead agency in the issuance of the National Pollutant Discharge Elimination System (NPDES) permit mandated by Congress through the Clean Water Act of 1977 (Chapter 342D, HRS). Dischargers of aquaculture effluent are required to meet applicable NPDES effluent guidelines and State Water Quality Standards (WQS). Implementation of WQS is through Hawaii Administrative Rules, Title 11, Chapter 54 (Chapter 11-54, HAR). Federal exemptions are available for aquaculture effluent discharges from facilities producing less than 100,000 pounds of aquatic animals per year and for facilities that discharge less than 30 days a year. DOH also may grant Zones of Mixing to allow effluent discharges that have implemented the "best degree of control" even though they are unable to meet the WQS. Limited zones are intended to place controls on discharges in order to attain the highest level of water quality and minimize environmental impacts on receiving waters. Anyone who proposes a discharge that results in a change in water quality must demonstrate important economic or social benefit and show that it will not interfere or adversely impact the intended beneficial uses of any State waters.

Under Chapters 328-9 and 321-11, HRS, Chapter 11-35, 11-29 and others, HAR, and the National Shellfish Sanitation Program (Pub. No. 33 U.S. Public Health Services), DOH is responsible for the inspection and regulation of shellfish including the growing, harvesting, packing and shipping of oysters, clams and mussels.

The Department of Land and Natural Resources (DLNR) is the lead agency for aquaculture development and for land-use decisions involving conservation lands in Hawaii. The State Land Use Law (Chapter 205, HRS), the Coastal Zone Management Act (Chapter 205A, HRS) and several similar mandates provide the basis for State land-use management in Hawaii. Land-use law establishes four major land use classifications: urban, rural, agricultural and conservation. The Land Use Law establishes jurisdiction between the State and the four County governments. Most urban land is under County control, as is agricultural land in parcels under 15 acres. Conservation land and large agricultural tracts are under DLNR jurisdiction. Aquaculture/mariculture is defined as a permitted use in both the agricultural and conservation classifications. State Conservation Land Use Permits generally are required by DLNR for projects within areas zoned as conservation lands.

Along with DOH, DLNR oversees groundwater allocation decisions and the withdrawal of water from streams. DLNR also oversees modification of stream channels on windward Oahu and use of groundwater in Oahu's Ewa and Wahiawa. DLNR is further responsible for historic site review of projects affecting designated or potential Federal and State Historic Sites, including many ancient Hawaiian fishponds.

The Hawaii Coastal Zone Management Law (Chapter 205A, HRS) requires State agency permit decisions to be consistent with the objectives and policies in the Law. The law sets broad policy regarding the use of coastal resources. It is administered by the Hawaii Coastal Zone Management (CZM) Program, Office of State Planning.

The Department of Agriculture (DOA) requires permits for the importation of non-indigenous species of aquatic animals. Certain species, commonly aquacultured on the Mainland, such as striped bass, some species of tilapia and freshwater eels, are not permitted for importation into Hawaii due to concern over unknown environmental impacts.

The Department of Transportation (DOT) has authority over activities within State waters (Chapter 266, HRS) and requires permits for filling/dredging, construction and placement of structures in shorewaters. Joint processing of DOT Shorewaters Permits with Conservation District Use Permits may be allowed.

County Authority

Landward of the shoreline, Counties have jurisdiction under the State Land Use Law, Special Management Area (SMA) and Shoreline Setback regulations, and County planning, zoning and subdivision laws. Under Chapter 205A, HRS, the four Counties are required to establish SMA boundaries and an SMA permit process for lands extending from the shoreline to no less than 100 yards inland. Developments within the SMA must conform to the objectives and provisions within the Hawaii Coastal Zone Management Law. The permit-granting authorities are the planning commissions for Kauai, Maui and Hawaii Counties and the City Council for the City and County of Honolulu. Applicants for an SMA permit must file a document that includes an identification of the property, plans, a description of the proposed development, a shoreline survey (if on the shoreline), and a description of the environment affected. Evidence must be provided that no serious environmental or ecological impacts will occur. Act 200 adopted by the 1979 State Legislature amends Chapter 205A, HRS, to allow exemption from SMA permits for aquaculture activities which are not or may not become "part of a larger project, the cumulative impact of which may or may not have a significant envionmental or ecological effect" on the SMA.

Chapter 205A, HRS, Part II and III, require that the Counties establish shoreline setbacks no less than 20 feet and no more than 40 feet inland from the shoreline (although Counties may extend the setback further by County ordinance). The law is intended to control development on the shoreline, prevent erosion, maintain open space, and preserve public access to the shoreline. Administration and enforcement of shoreline setbacks are the responsibility of the County planning departments (Kauai, Maui and Hawaii) and the Department of Land Utilization of the City and County of Honolulu. Variances may be issued following a review by the appropriate County authorities. Other general building permits also may be needed. County public works departments generally require grading, grubbing and stockpiling permits for major land clearing developments. The City and County of Honolulu also requires a well permit for the construction of or modification to fresh, brackish or saltwater wells.

Support

Federal Authority

On the Federal level, the Department of Agriculture (USDA) and Department of Commerce (DOC) have been major supporters of aquaculture in Hawaii, providing over $6.4 million in grant funding in 1987 alone. In addition, USDA made a substantial commitment to aquaculture on a national level in 1985 with the establishment of four (now five) regional centers to support aquaculture development. One of those centers, the Center for Tropical and Subtropical Aquaculture (CTSA), is in Hawaii. Jointly administered by the University of Hawaii and the Oceanic Institute, CTSA is a programmatic center that funds and administers research, development and demonstration projects throughout the U.S.-affiliated Pacific Islands (DLNR 1987; 1988; Main et al 1987).

In addition, USDA provides nationwide aquaculture support through matching grants to States through its Agricultural Marketing Service; extension services through State Cooperative Extension offices; Farmers Home Administration loans; Federal crop insurance; National Agricultural Library Service; statistical reporting services and purchase of aquaculture overproduction.

Other Federal agencies, including the Department of Interior (DOI) and DOC support research, development, extension and training for aquaculture activities. DOI works primarily through the US Fish and Wildlife Service. DOC supports aquaculture research and development activity through the Economic Development Administration (EDA) and National Oceanic and Atmospheric Administration (NOAA). NOAA conducts its research and development programs primarily through the National Marine Fisheries Service and Sea Grant College Program. Additional Federal support for aquaculture, primarily financial aid, is available through loans from the Farmers Home Administration and the Small Business Administration, and grants from the National Science Foundation.

Federal and State grants to fund aquaculture research have been rising since 1980, when support totaled about $2 million. In 1985 State and Federal aquaculture grants exceeded $6 million. State funds are primarily administered by DLNR's Aquaculture Development Program and are often matched by UH Sea Grant College Program and occasionally by private sources. Hawaii also has received recognition from the Federal government for its leadership role in aquaculture development. The State was selected in 1987 by Congress as the site of the Center for Applied Aquaculture (CAA). CAA will serve national aquaculture research needs. It is expected to employ 300 persons and be a foundation for approximately $40 million to $60 million in research contracts annually (ibid).

State Authority

In 1978, Hawaii became the first state to issue a comprehensive aquaculture development plan (DPED 1978). The State has long had a commitment to developing an aquaculture industry. As early as 1961, the Honolulu Bait Station (later consolidated into the Anuenue Fisheries Research Center, AFRC) began State-funded research into culturing tilapia for use as baitfish. In 1965, the State pioneered freshwater prawn aquaculture and for over a decade has provided postlarval prawn stock to local aquaculturists. The AFRC continues to provide extension services regarding a variety of marine and freshwater species (Main et al 1987).

In 1977, the State Aquaculture Development Program (ADP) was established in the Department of Planning and Economic Development (now the Department of Business, Economic

Development & Tourism, DBED). ADP is the lead agency for: 1) statewide planning, coordination and communication; 2) providing information-related support services, permit acquisition, species and site selection, marketing and economics, and disease diagnosis and prevention projects; and 3) funding and co-funding research, development and demonstration projects. In 1981, ADP was transferred to DLNR to consolidate resources under one lead agency.

The Natural Energy Laboratory of Hawaii Authority (NELHA) was created from the separate entities of the Natural Energy Laboratory of Hawaii and the Hawaii Ocean Science and Technology Park. NELHA has used the deep seawater byproduct of the Ocean Thermal Energy Conversion (OTEC) projects it oversees to support aquacultural research and production. NELHA comprises over 870 acres reserved for high technology ocean-related research, development and commercial activities. Staff, expertise, equipment and utilities are available for aquacultural support. In 1989, eight companies produced 13 different aquacultural products (some sold to Mainland markets) and employed 140 people (DLNR 1989).

Besides ADP, the Division of Aquatic Resources (DAR) has aquaculture responsibilities which include hatchery operations, research, stock enhancement and development activities. Through its AFRC facility, DAR became the main supplier of prawn post-larvae seed stock on an emergency basis after private hatcheries closed down.

In 1985, the Legislature authorized the establishment of the Hawaii Aquaculture Advisory Council (HAAC) to advise DLNR on aquaculture development in the State. The Council is composed of 16 ex-officio members from key State agencies and County governments and seven aquaculture industry representatives (DLNR 1984).

The University of Hawaii offers training and research facilities through 13 of its departments or programs including: the College of Tropical Agriculture and Human Resources; College of Natural Sciences; Hawaii Institute of Marine Biology; Hawaii Backyard Aquacultural Program; Mariculture Research and Training Center; the Snug Harbor Algal Mass Culture Facility and Waikiki Aquarium. The University has an aquaculture coordinator who emphasizes development for research and extention outreach to industry. The UH Sea Grant program funds innovative research and development projects and offers extension help throughout the Islands. The University offers degree programs related to aquaculture through its Marine Options Program and the Hilo campus has a degree program offering an aquaculture major (DLNR 1984; Main et al 1987).

The State has recognized the need for a large-scale aquaculture pond research and training facility to simulate the environment in which most commercial aquaculture is produced. The University of Hawaii's Mariculture Research and Training Center (MRTC) at Hakipuu, Oahu, was selected as the site for Phase 1 of this facility, with satellite facilities to be built on one or more of the Neighbor Islands (DLNR 1989).

In addition, the State has provided significant financial support for development of the aquaculture industry. DOA administers the Aquaculture Revolving Loan Fund (ARLF) to help finance commercial aquaculture activities. By law, ARLF can loan up to $100,000 for real estate and improvements and up to $75,000 for operating capital. Since its establishment in 1972, 38 loans totaling $1,670,000 have been made. Loans from the ARLF are not available to aquaculturists involved in the production of ornamental fish (ibid).

County Authority

Maui County, long a leader among the Counties in aquaculture research, is the only County supporting aquaculture development. The Maui County Baitfish Facility, founded in 1978, investigated development of top minnows for use as bait for skipjack tuna fishing. Tilapia and catfish also were being investigated for human consumption. Facilities include six .2-ha ponds and three .05-ha broodstock ponds. There are four full-time County employees (Main et al 1987). In 1988, Maui County also funded the first cottage-level aquaculture project in the State. Managed by Maui Economic Opportunity, Inc., senior citizen participants cooperatively marketed Chinese catfish, snails and tropical fish grown in backyard fish farms.

Maui is now looking into establishment of a 107-acre research facility called the Kealia Aquatech and Renewable Resources Park (KARRP) as a technology incubator focusing on renovation, pilot testing or pre-commercial development phases of projects. The County also has funded a marine shrimp hatchery on Molokai to provide post-larvae seed stock to the two marine shrimp farms there. Maui County also is joining various State and private agencies in funding a project to use a traditional Hawaiian fishpond in the culturing of mullet and milkfish (DLNR 1989).

MANAGEMENT ISSUES

Management issues associated with aquaculture in Hawaii fall into six major categories: land availability and expense; water availability; public access and user conflicts; environmental concerns; regulatory constraints and lack of coordination among management agencies; and economic viability concerns.

Land Availability and Expense

Although the Aquaculture Development Plan (DPED 1978) has identified 135,000 acres as suitable for aquaculture and an additional 500,000 acres as having potential for aquaculture, land ownership, development conflicts and the high cost of land for purchase or lease seriously restrict this ideal. Only a fraction of that acreage is currently available for aquaculture development. Government support of aquaculture, such as the aquaculture park at NELHA on the Island of Hawaii, can help alleviate this situation. Some suggest expanding the aquaculture park system to other Islands. Offshore aquaculture development also could alleviate some of the cost associated with land acquisition and the unavailabity of suitable land.

Water Availability

Water availability may be broken down into three categories: brackish, salt and fresh. There are substantial brackish water and almost unlimited saltwater resources available for aquaculture today and in the future. The supply of fresh water is adequate for current aquaculture production. Although the visitor industry, golf courses, diversified agriculture, a growing population and new industrial development put pressures on freshwater supplies, it is important to note that fresh water used for aquaculture often can be integrated into agriculture as irrigation water and thus "used" more than once. The decline of other agriculture sectors, such as sugar and pineapple, may free some fresh water for the aquaculture sector. This issue is likely to become more heated as competition for fresh water increases. Setting priorities for water use and reuse and encouraging brackish and saltwater aquaculture development may help mitigate future problems.

Public Access and User Conflicts

Aquaculture farms and research facilities have reported serious economic losses due to theft in recent years. Shoreline fishponds seem particularly vulnerable to losses from theft. Enrichment of the natural environment from aquaculture effluent and nutrients may increase fisheries around offshore aquaculture structures, thus attracting fishermen and poachers as well as fish.

Aquaculture is primarily located along shoreline, near-coastal or coastal water areas. Expansion of the industry could restrict access to these areas and raise the question of traditional access versus property rights. View planes and view obstruction may occur because of offshore aquaculture structures, pens and cages. Traditional public rights, such as access to the shoreline from the land or the sea and the public use of fisheries as common resource, including traditional native tenants rights, make user conflicts likely.

Environmental Concerns

As aquaculture in Hawaii is still a relatively small and environmentally benign industry, there is little evidence of adverse environmental effects. As the industry expands there may arise environmental concerns that might be better addressed sooner than later. Among them are effluent discharge and the accidental release of imported species into the ecosystem.

Effluent discharges from aquaculture facilities generally contain a high amount of nutrients due to uneaten feed, unabsorbed fertilizers and/or waste elimination from the animal stock. Chemical agents used to prevent disease may be present in the discharge, as well as hormone additives that might be used to accelerate growth. Such nutrient enhancement of the natural environment could stimulate the growth of plankton and neritic and benthic biota. The effects of such biostimulation may be viewed as positive, neutral or negative, depending upon the specific results and biases of the interpreter. Additional assessment needs to be done concerning the environmental effects of aquaculture effluent discharge into coastal waters.

The construction of shoreline and offshore aquaculture facilities may further complicate issues. Construction along shoreline areas could conflict with the Special Management Area (SMA) mandate to protect, preserve, develop and restore Hawaii's coastal zone resources. However, aquaculture may be able to further the SMA mandate by utilizing restored traditional fishponds, restocking depleted fisheries and, effecting positive effluent discharge-related biostimulation.

The inadvertant importation of exotic species to Hawaii has caused the endangerment or extinction of many indigenous plant and animal species. Although this is not primarily an ocean concern, there are known cases of marine species importation and spread. *Euchema*, a seaweed, has "escaped" outside enclosures and spread throughout Kaneohe Bay. Tilapia has spread to most brackish water areas in the state. There is concern that a more predatory species, such as an eel, could do long-term or permanent damage to the ecosystem. Since most of the species which have proven to be viable for aquaculture are nonindigenous to Hawaii, responsible, proactive management in this area is important.

Regulatory Constraints and Lack of Coordination

Myriad agencies on all levels of government regulate and control aquaculture in Hawaii. Many of these agencies or governing bodies have limited knowledge of aquaculture, that is a unique industry. Restrictions and regulations which may seem valuable to the regulatory agency may not in fact be relevant, and thus, may make public participation in aquaculture development more difficult (DLNR 1989).

Restrictive policies and a complicated permit-granting process also hinder the start-up and expansion of new aquaculture businesses. This is especially true for small businesses lacking financial and in-house technical resources. The current permit process is thought to limit the development of farms, impede lender or investor financing at the early stages of development, require costly legal, engineering and environmental expenses; commit technical and mangement people to nonproductive time-consuming meetings, strategy sessions, public hearings, and coordination with consultants; add to construction costs; and impose significant and long-term costs for monitoring and reporting to government agencies (DLNR 1987; 1988).

Given the range of goals and objectives that governmental agencies seek to follow, it is inevitable that some conflicts among development and resource protection policies will occur. Coordinating bodies such as ADP and HAAC help unify on a Statewide level the various approachs to aquaculture development now undertaken by Federal, State and County governing agencies. Recent steps have been taken in this direction. This increased coordination among government agencies should be encouraged along with increased input from the private and research-oriented sectors. ADP has been helpful in obtaining permits and is currently working on

methods to further facilitate proactive coordination beteween permitt-granting agencies.

Economic Viability

Lack of capital is perhaps the biggest constraint to start-up or expansion of commercial aquaculture production facilities in Hawaii. Private lenders are unwilling to risk capital on a new industry, which they may not understand and may correctly perceive as high-risk. Bankruptcies and the withdrawal of support by several large corporate aquaculture operators in the State have furthered apprehension. Start-up costs are especially high for small-scale and community-oriented ventures. Suitable seed stock often is unavailable and feed expenses are high.

Despite the above, the future for aquaculture in Hawaii could be very bright. Federal and State programs are encouraging increased participation. More people are eating fish at a time when traditional fisheries are approaching their optimal level of production. Hawaii already has played a major role in the culturing of freshwater prawns worldwide. Expansion of Hawaii's expertise into other areas, such as the production of further food species, culturing stock for depleted ocean fisheries, and exploration into biotechnology, medicine and industrial products could help Hawaii diversify its economy and adapt to environmental and economic situations. A diversified, small-scale, locally oriented production sector could help increase Hawaii's self-sufficiency and provide the beginnings of a stable economic and food production base for the State. Continued concentration on basic and applied research can further export earnings as the service and consulting sector gains prominence on the Mainland and worldwide. Large-scale operations, if proven viable, also can increase export earnings and provide needed jobs in a diversified economy.

RECOMMENDATIONS

Objective

Develop an integrated approach to manage the impacts associated with an expanded aquaculture industry in Hawaii, while maintaining the viability and integrity of the environment.

Policy A

Assess the economic, social, and environmental costs and benefits of expansion in the various sectors of the aquaculture industry.

Implementing Actions:

DLNR should:

1. Identify the positive and negative impacts of expanding the various sectors of the aquaculture industry.

2. Establish priorities for support of the various industry sectors.

3. Create a coordinated development strategy to direct the industry along the path most beneficial to the economic, social, and environmental well-being of Hawaii.

4. Consider the needs of the aquaculture industry for fresh water in relation to competing water uses.

Policy B

Mitigate user conflicts between the aquaculture industry, fishermen, and the public at large.

Implementing Actions:

DLNR should:

1. Investigate alternative means to resolve disputes between these communities.

2. Investigate the feasibility and desirability of expanding the Ocean Leasing Law to allow commercial aquaculture facilities in nearshore waters.

3. Encourage new aquaculture farms and facilities to begin a dialogue with affected community groups early in the development process.

Policy C

Assess the impacts of aquaculture on the Hawaiian ecosystem.

Implementing Actions:

DLNR, in cooperation with DOH, should:

1. Investigate the environmental effects of aquaculture effluent discharge now occurring in Hawaiian waters.

2. Evaluate State regulations governing discharges and suggest possible changes to Federal and County regimes.

3. Develop a strategic and coordinated management plan to prevent adverse environmental impacts from aquaculture discharges, such as the identification and development of suitable sites around the State.

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ENERGY

THE RESOURCE

Hawaii's ocean waters are a major energy resource, particularly important in a State whose relative isolation renders it hostage to imported oil. While the State supports many forms of alternative energy research and development, it has focused undeniably on the ocean. During the 1980s, Hawaii became the premier site for Ocean Thermal Energy Conversion (OTEC) research and implementation. OTEC facilities are designed to replace fossil fuel electrical generation capacity. In a State where the greatest energy demand lies in the transportation sector, OTEC's capacity to displace fossil fuel use will be limited for the next decade. Nonetheless, the ocean has much to offer in alternative sources of energy for the future, through OTEC and other marine energy technologies.

In addition, the conventional energy facilities already in place in the State affect the ocean directly in a number of ways. Oil-burning electrical generation plants are sited near the ocean and use ocean water for cooling systems. Hawaii's primary energy source, crude oil, arrives entirely by tanker. Statewide use of geothermal energy resources is technically feasible given advanced transport systems—either design and deployment of what will be the world's deepest underwater power transmission cable, or the production and shipping of hydrogen throughout the State. Appropriate ocean management policies and appropriate energy strategies must recognize the ocean's potential as an energy resource as well as its present relation to existing energy facilities.

Demand

In 1988, Hawaii's resident population totaled over 1,098,000, with a de facto population of approximately 1,219,000[1]. Energy consumption for that year totalled almost 313 trillion Btu; this equals approximately 285 million Btu per capita for the resident population, or approximately 45 barrels of oil per person (barrels of oil equivalent, total energy use)[2]. Looking at State consumption patterns by sector, 1987 figures show that of a total 234.6 trillion Btu of energy consumed, 9.4 percent was residential use; 12.5 percent was commercial use; 24.5 percent was industrial use; and the remaining 53.6 percent was used in the transportation sector.

Hawaii's energy demand pattern is unique among the 50 states, and with respect to the nation as a whole. With the State's economy dependent on the tourist industry, jet fuel use is comparatively high, with air transport the primary consumer in the transportation sector. In the rest of the country, ground transport is the primary consumer in the transportation sector. As virtually no consumer demand for heating exists in Hawaii, residential energy use is comparatively low. The State's relative lack of heavy industries also reduces its total demand for fuel oil and electricity.

In 1987, almost 45 million barrels of oil or equivalent in products were consumed in Hawaii. The State's transportation sector alone accounted for 60 percent of oil demand. The total 1988 liquid fuel tax base equalled 1.22 billion gallons, of which over 701 million gallons were aviation fuel. Electric utilities are the second-largest users of oil, at 26 percent of total State demand. In contrast, transport for the country as a whole equals only 27 percent of total energy consumption, and electricity generation over 35 percent. In the future, fresh water production may become another energy sink in Hawaii's energy demand pattern. The State's new desalinization plant at Barbers Point focuses on a new, potentially very large energy demand sector.

Supplies[3]

Hawaii's energy supply picture is also unique. In 1988, petroleum supplied over 91 percent of the State's primary energy needs. All of that petroleum was shipped to the State. About 60 percent of it originated within the United States (primarily from Alaska's North Slope fields). Biomass (principally sugar cane bagasse) supplied 8 percent of Hawaii's primary energy needs, and solar water heating, hydroelectricity, wind power and geothermal power together provided only 1.2 percent. In contrast, in 1988, the nation as a whole depended upon petroleum for only 43 percent of its total energy needs; upon coal and gas for 23.5 percent and 23.1 percent, respectively; nuclear power accounted for 7.1 percent; hydroelectricity for 3.3 percent; and all others for 0.3 percent.

Looking at electricity generation alone, petroleum fueled 91 percent of Hawaii's electricity generation in 1988, with biomass generating seven percent, and the remaining two percent or so generated by hydropower, wind power and geothermal power combined. The utilities generated about 89 percent of Hawaii's electrical demand. Plantations and other private companies generated the other 11 percent, most of which was sold to electrical utilities under contract.

Of the conventional energy sources — petroleum, natural gas, coal — Hawaii has absolutely no reserves to answer its energy demand. Even if construction of nuclear fission plants in the State were not against the law, Hawaii's electricity demand would be insufficient for fission's economies of scale. Average plant size for nuclear fission electrical generation is approximately 1000 MW. Oahu's peak demand is about 1000 MW, with baseload requirements of about 600 MW. Given any generating plant's downtimes, it is impractical to build electrical plants the output of which exceeds one-third of baseload demand. The recycling and burning of garbage, while using an indigenous energy "resource," also raised some ire among voters. Public sentiment is untested with regard to nuclear fusion, but history suggests feelings would run high on that issue as well. However, should commercial nuclear fusion become possible, Hawaii at least can claim abundant supplies of "heavy water" for deuterium in the surrounding oceans. The only indigenous sources of energy available to the State are solar power, wind power, geothermal power, biomass and the various "water powers:" hydropower, OTEC, and tidal and wave generators.

Implications for Ocean Resource Management

Given Hawaii's lack of conventional energy resources and heavy reliance on imported petroleum, development of all practical alternative energy systems is a necessity. This includes continued research and development in energy systems that may not be viable at the present. First among the alternatives is energy conservation. The State mandates not only integrated resource planning by electrical utilities, but also demand-side management and conservation programs. As statistics indicate, Hawaii already strongly supports alternative energy use: 9.2 percent of its primary energy needs are met by non-conventional sources, compared to only 3.5 percent for the United States as a whole.

The ocean resource management program should encourage optimal development and use of the State's ocean energy resources. The primary ocean and ocean-related energy resources to consider currently are OTEC, tidal and wave power generators, and marine biomass. Where to put energy facilities raises both social and environmental issues, which must jointly be addressed by ocean resource management and energy plans. Finally, both underwater electrical transmission cables and surface transport for conventional fuels should be managed to balance efficiency of delivery with safety. Optimal development and use of these ocean resources should not preclude maintaining and enhancing marine environmental quality.

Ocean and Energy Production

Energy Sources in Ocean Waters

The Pacific Ocean is one of the planet's primary energy engines. As it absorbs sunlight, the subsequent temperature shifts in the water drive not only cloud formation but the flow of winds and the generation of storms. This thermal energy can be tapped indirectly, as wind power, marine biomass fuel, and wave power, or directly as OTEC. The ocean is not merely a planetary, but an interplanetary energy sink: the gravitic forces generated among the sun, the moon, and Earth generate tides, and this energy also may be captured for use. Hawaii's wind generators are all land-based, so ocean energy management is currently limited to marine biomass, wave power, OTEC and tidal power. On a worldwide scale, however, these sources alone could meet planetary power needs (Table 1).[4]

Table 1

Estimated Technically Feasible Ocean Energy Resource Potentials (in MW*)

Thermal conversion	10,000,000
Wave power	500,000
Tidal power	200,000
Salinity gradients	3,540,000
Bioconversion	770,000
Currents	50,000

*megawatts

Source: Riva et al. [16:23], cited in Pryde, Philip R., *Nonconventional Energy Sources*, New York: John Wiley & Sons, Inc., 1983. p.101.

Marine biomass can generate methane for a variety of energy end-uses. Conceptual designs to date have suggested cultivating both giant kelp and red seaweed, grown in plantations fertilized by nutrient-rich deep seawater. This deep seawater would be pumped to the near-surface waters in a form of artificial, mechanically assisted upwelling. As the pumps for upwelling would themselves consume energy, these designs are most viable when linked to wave energy or OTEC plants. However, yields under experimental conditions have confirmed that seaweed plantations could easily be 15 tons dry weight per acre per year, which is comparable to the best land-based biomass production. As supplementary products, the plantations also would produce animal food and fish.

Every surfer knows that ocean waves are power. Mechanically, the trick is converting the multidirectional, varying power of the wave into unidirectional mechanical energy and thence to electrical power. Hundreds of designs exist to do so, including hydraulic pumps, pneumatic pumps, rotation vanes and hinged rafts. While fuel costs for these technologies are nonexistent, and operating costs low, capital costs would be very high for any installation large enough to provide community power. As long as oil prices remain below $50 per barrel, none of these designs will be economically viable.

Tidal power generators require a tidal range of at least five meters to be economically viable using conventional technology. Only shallow estuaries and embayments, which concentrate tidal forces, see such high tidal ranges. Relatively few suitable sites exist on the planet, and none of them are in Hawaii.

Marine biomass plantations, wave power generators and tidal power generators have not generated great interest in Hawaii. But OTEC research in the State has continuously expanded since 1975, supported by Federal, State, private and international sponsors. In 1975, the Natural Energy Laboratory of Hawaii Authority[5] (NELHA) established the Kona Seacoast Test Facility on 328 acres of oceanfront land at Keahole Point on the Big Island.[6] Designated as the primary site for OTEC research in the United States, OTEC-related experiments have been ongoing since it opened. Applied research began in 1979, with the construction of "Mini-OTEC," a pilot closed-cycle OTEC plant build on a converted Navy barge. This plant produced a 52-kw gross output of energy, and a 15-kw net output of energy. It was the first closed-cycle plant to produce a net output of electrical power.

OTEC is a method of converting the renewable solar energy stored in the ocean into electrical energy. Two main components comprise the system: warm and cold seawater intake and discharge pipes; and the power plant itself, consisting of pumps, turbine generators and heat exchangers. Warm surface seawater and cold deep seawater are piped separately to a power plant where the temperature differential, which must be at least 20°C, is utilized in either closed-cycle or open-cycle thermal energy conversion. In a closed-cycle plant, the warm sea water vaporizes a working fluid, such as ammonia, which drives a turbine generator; the cold seawater then condenses the working fluid to produce a continuous cycle. In an open-cycle plant, warm surface seawater is vaporized in a depressurized chamber, producing low-pressure steam for power generation. The cold water is used to condense the steam: this process incidentally produces large quantities of desalinated water as a byproduct. The cost effectiveness of the open-cycle plant is enhanced by the production credit from this byproduct. Fresh water also can be produced through closed-cycle OTEC with the addition of a conventional desalination unit or a second stage consisting of a flash evaporator and a surface condenser (ie., an open-cycle OTEC system without a turbine). This system is referred to as an hybrid OTEC plant.

More exciting than the ocean energy research itself is the rich basket of commercial opportunities that have resulted from innovations based on the cold seawater pumped to condense the working fluid in an OTEC plant. This cold, nutrient-rich deep seawater can be applied innovatively to air-conditioning, agriculture and aquaculture. NELHA has installed an airconditioning system using chilled-water coils in one of its laboratory buildings, resulting in considerable energy savings. Research projects cultivating temperate zone fruits and vegetables have produced lettuce and strawberries in gardens cooled and irrigated with the fresh water condensing on the external surfaces of the cold seawater pipes. As for aquaculture, the cold seawater not only allows means of fine-tuning tank and pond temperatures for thermally sensitive fish, shellfish, mollusks and seaweeds, but it is nearly pathogen-free and very nutrient-rich. This enables aquaculture projects to produce premium microalgae, *nori*, abalone, oysters, giant clams, lobsters, salmon and trout. However, at present there are no commercially viable species for cost-effective, OTEC-based mariculture operations. OTEC mariculture is in its formative years and not ready for commercialization. With the exception of the relatively small use of the cold seawater as air-conditioning chiller fluid, OTEC should be considered for its potential production of electricity and desalinized water.

In the decade between 1979 and 1989, steadily growing interest in OTEC research and related activities transformed the land surrounding the Seacoast Test Facility at Keahole Point into the Hawaii Ocean Science and Technology (HOST) Park. It has seven cold-water pipes in place, and 14 tenant projects. Of these, four are OTEC energy research projects, six are aquaculture research projects and four are commercial aquaculture ventures. Of the 869 acres at HOST Park, 416 are committed to ongoing or proposed projects. OTEC demonstration projects are planned for the near future. A 210-kw (gross) land-based, open-cycle plant is under design and scheduled for construction at NELHA in mid-1991, with operations scheduled for July 1992. This plant is a joint project of the U.S. Department of Energy, the State and the Pacific International Center for High Technology Research (PICHTR). The plant is designed to produce net power and is therefore referred to as the Net Power Producing Experiment (NPPE). Several proposals for closed and hybrid-cycle plants ranging from 160 to 500-kw (gross) are being pursued by Hawaiian outfits.

The cost of electricity produced with OTEC plants has been compared to that of electricity produced via petroleum or coal-fired plants (Vega 1991). Two generalized markets were considered: industrialized nations with land-based or floating plants and smaller, less-developed island nations with modest needs and therefore, small, land-based plants. The model is used to establish scenarios under which OTEC could be competitive. The scenarios are defined by two parameters — fuel cost and cost of freshwater production. The results of the analysis are summarized in Table 2.

One can envision 40-MW hybrid plants for the Islands of Hawaii and Kauai meeting all water and electricy needs under the scenario provided in Table 2. Likewise, smaller (10-MW) plants can be considered for Molokai. In the case of Oahu, the population is too large to meet all electrical needs with OTEC. However, all water needs can be met with hybrid OTEC plants. The hybrid OTEC plants considered above would have the following production rates:

Plant Size	Electricity Production	Water Production
10-MW	70 X 10^6 kWh	4 to 8 million gpd
40-MW	280 X 10^6 kWh	16 million gpd

The cost per kWh (expressed in current dollars), including a credit for freshwater production, would be 0.10 $/kWh for the 10-MW plant, 0.09 $/kWh for the 40-MW plant. These plants could be commercially available before the turn of the century if some of the demonstration projects under consideration come to fruition. The financial community will not invest in new technology without an operational record.

As a point of comparison, consider that in 1988 residential electricity costs were almost 0.08 $/kWh for Oahu; 0.11 $/kWh for Hawaii; 0.12 $/kWh for Kauai; almost 0.10 $/kWh for Maui; almost 0.16 $/kWh for Lanai; and almost 0.20 $/kWh for Molokai. Therefore, OTEC for the State is promising, pending the construction and operations of demonstration plants.

Table 2

OTEC Market Penetration Scenarios

NOMINAL NET POWER NET POWER (MW)	TYPE	SCENARIO REQUIREMENTS	SCENARIO AVAILABILITY
1	Land-Based OC OTEC with 2nd-Stage additional Water Production	• $45/barrel of diesel • $1.6/m3 water	South Pacific Island Nations by Year 1995
10	Land-Based (as above)	• $25/barrel of fuel oil • $0.85/m3 water — or — • $22/barrel • $0.8/m3 water	American Island Territories and other Pacific Islands by Year 2000
40	Land-Based Hybrid (ammonia power cycle with flash evaporator downstream)	• $44/barrel of fuel oil • $0.4/m3 water — or — • $22/barrel • $0.8/m3 water	Hawaii, if fuel or water cost doubles by Year 2000
40	• Closed-Cycle Land-Based • Closed-Cycle Plant ship	• $36/barrel • $23/barrel	by Year 2005

Note: OC-OTEC limited by turbine technolgy to 2.5 MW modules or 10 MW plant (with four modules).
CC-OTEC or Hybrid (water production downstream of closed-cycle, plant flash evaporator).

Ocean-Based Energy Distribution

Underwater Electrical Transmission Cables[7]: In October 1981, the State initiated the Hawaii Deep Water Electrical Transmission Cable Demonstration (HDWC) Program in conjunction with the Federal government and in cooperation with Hawaiian Electric Company. Its purpose was to research and develop a deep water electrical transmission cable and support system to deliver electricity from renewable energy sources on the Big Island to consumers on Oahu. The State's largest energy market, Oahu, has no large-scale indigenous firm power sources. The undersea cable could transmit up to 500 megawatts of electrical power, almost half of Oahu's current demand. This system also could provide back-up electrical power to other Islands should power emergencies arise (Sumida and Hills 1984).

By 1988, sonar surveys and unmanned submarine surveillance determined the selection of a preferred undersea cable route between Hawaii and Oahu from nine suggested routes. This route begins at Puna on the Big Island, moves north and west to Waimea over land, than crosses the Alenuihaha Channel to Maui at a depth of 6,350 feet. On Maui, the cable comes onto land at Huakini, crossing the southern tip of the Island to submerge again at Ahihi. From there, it runs northwest past Lanai and Molokai, through the Auau Channel at a depth of only 410 feet, before heading across the Kaiwi Channel under 2,240 feet of water to Waimanalo on Oahu.

In 1989, the project had progressed to successful laboratory testing of a 300-kv DC self-contained oil-filled cable. As the final phase of the feasibility study, the 273-foot vessel Flexservice 3 laid and retrieved a 26,000-foot, non-electrical test cable in order to prove technical capability of cable installation and maintenance. To further link all the State's customers into a baseload power grid, Maui Electric Company (MECO) initiated feasibility studies to test the economics of installing submarine transmission cables between Maui, Molokai and Lanai.

The cable project will be implemented in conjunction with the development of a 500-MW geothermal generation plant on the Big Island in a joint effort called the Hawaii Geothermal/ Interisland Transmission Project. In May 1989, Hawaiian Electric sent out a Request for Proposals to 33 organizations to finance, design, construct, install, operate and maintain a 500-MW geothermal generation/interisland transmission project. Also that year, the State awarded a major contract to ERC Environmental and Energy Services Company to prepare the project's master plan and environmental impact statement, and to analyze overland electric transmission corridors.

Petroleum Transport and Storage: Oahu has two oil refineries, both in Campbell Industrial Park near Ewa Beach. The older of the two is owned by Chevron. The Hawaii Independent Refinery, Inc. (HIRI), owned by Pacific Resources, Inc. (PRI), is newer and more sophisticated. Their total combined processing capacity is approximately 135,000 barrels per calendar day (Table 3). Supplying this capacity with crude oil requires about ten tanker deliveries every month. The tankers load and unload at mooring buoys situated in waters off Barbers Point. The closest of these facilities is 1.5 miles offshore. The loading cycle may take as long as two days.

About 60 percent of the crude oil landing in Hawaii originates in Alaska. Tankers from Alaska usually approach Barbers Point via the Kauai Channel. Kaiwi Channel is used on occasion

Table 3

Hawaii's Refineries

	HIRI	CHEVRON
REFINERY CAPACITY (barrels/day)	80,000	55,000
STORAGE CAPACITY in million barrels (no. of tanks)		
CRUDE OIL	1.8 (6)	1.6 (7)
PRODUCTS	2.4 (50+)	
TANKER SIZE (median)		
in deadweight tons	35,000	97,000
deliveries/month	8	3
LOADING/UNLOADING*		
mooring buoy type	monobuoy	fixed-point
miles offshore	2	1.5
loading cycle (days)	1.5 - 2	1 - 1.5

* Chevron only unloads.

Sources: Conversations with PRI and Chevron staff, January 1990.

by vessels coming from Alaska, but Kaiwi is more often the approach of choice for vessels from the West Coast. This approach puts the entire south shore of Oahu at risk from crude oil spills. Tankers call at the other Islands as well. These ships are most often product tankers, filled with fuel oil, motor gasoline, or jet fuel. Just under half of the products delivered are light distillates, while more than half are heavy oils (Table 4). In the case of Maui, tankers approach from the north, and moor to the north, at Kahului. The north shore of Maui is at risk of spills, as are Molokai, Lanai and Oahu, as winds and currents would move the spill west and south.

Utilities operate 13 oil-fired electrical generating plants in the State, with plantations operating a dozen more electrical plants, which burn either oil or bagasse. Of the oil-fired power plants, three are on Oahu, five on the Big Island, two on Maui, and one each on Kauai, Molokai and Lanai. The three Oahu plants are all near the ocean — at Kahe Point, Waiau on Pearl Harbor, and Honolulu's waterfront near Pier 7. The Maui power plants are in Kahului on Hobron Point, and at Maalaea, with capacities of 34.9 MW and 96.1 MW respectively. The Kauai power station at Port Allen has a total generating capacity of over 65 MW. Lanai and Molokai's plants have total capacities of 10.76 MW and 5 MW, respectively.

At least nine of these plants are situated within one-half mile of the shoreline. Whether they use well water or seawater as a steam source, these nine plants subsequently pipe the condensed but still warm water into the ocean. Maui's Kahului plant illustrates the relative amount of seawater return for a given capacity. The Kahului plant has four generator units that jointly produce almost 35 MW of power. The pumps on those four units each push between 3,700 - 4,000 gallons per minute (gpm) of condensed steam into the ocean, for a plant total of 37,900 gpm — or a little over 1,000 gpm per MW of plant capacity. The water is cooled before discharge to a federally regulated maximum temperature of 36.7°C, or 78°F.

Electricity also is produced in the state by small diesel generators; small hydroelectric plants, found on Maui, Kauai and Hawaii; wind farms, primarily on Oahu and Hawaii; and the burning of bagasse, on Hawaii as well as on Kauai, Maui and Oahu. Diesel, hydroelectric and wind farm facilities have very little impact on ocean waters. Sugar factories, however, do add significant amounts of pollutants to the ocean in the form of mill water waste discharge.

RESOURCE MANAGEMENT

Regulation and Enforcement

Electricity Generation: OTEC

State: All ocean energy development will occur under the authority of the State Department of Business, Economic Development & Tourism (DBED), according to Title 12, Conservation and Resources, Chapter 196-4, HRS. This statute appoints the Director of DBED as State energy resources coordinator, and charges DBED with the following mandates:

1. Develop Hawaii's energy resources at optimum levels.
2. Recommend to the Governor and Legislature, which programs represent best allocation of resources.
3. Develop programs to encourage public and private exploration of alternative energy sources.
4. Organize public education programs regarding energy.
5. Advise government, public and private sector on energy resource acquisition, utilization and conservation.
6. Contract for services to develop energy sources and resources.
7. Report to the Governor and Legislature annually on energy.
8. Adopt rules as needed to implement Chapter 196-3;4, HRS.

Table 4

Hawaii's Petroleum Imports and Exports

Product	IMPORTS [in 1,000 barrels] Total	Domestic	Foreign	EXPORTS [in 1,000 barrels] Total	Domestic	Foreign
CRUDE OIL	41,218	20,755	20,463	—	—	—
REFINED PRODUCTS	6,651	3,353	3,298	6,829	3,331	3,498
Motor gasoline	193	193	—	187	187	—
Distillates	217	217	—	1,658	1,067	591
Jet fuel	2,677	1,119	1,559	2,160	104	2,056
Rsd. fuel oil	3,563	1,824	1,739	2,524	1,673	851
Other	—	—	—	300	300	—

Note: "Jet fuel" excludes imports of 3,686,500 barrels of unknown origin.
Source: Department of Business and Economic Development, Energy Division, records: Section 17, Table 504.1.

These are primarily research and development, monitoring and planning activities. DBED issues no permits for energy development. Rather, it applies to other agencies for permits for its energy development projects.

Permits for all ocean energy projects generally involve the following agencies: the Department of Land and Natural Resources (DLNR); Department of Transportation, Harbors Division (DOT/Harbors); Department of Health (DOH); Public Utilities Commission (PUC); and relevant County planning commission (or, in the case of the City and County of Honolulu, the City Council). Ocean energy projects also fall into the purview of the State's Coastal Zone Management (CZM) Program. CZM objectives primarily are realized through the permit-granting, regulatory and management authority of those five agencies, with the Counties exercising the most authority via Special Management Area (SMA) zoning regulations. The CZM Program has responsibility for ensuring that federally funded or permitted projects are consistent with State and County coastal zone regulations.

Under Chapter 205, HRS, Hawaii's Land Use Law, DLNR is responsible for land-use regulations in Conservation Districts and Forest Reserves, including the Conservation District Use Application (CDUA) permit process; Marine Life Conservation Districts (Chapter 190-15, HRS); Fishery Management Areas (Chapter 187A-2, HRS); Natural Area Reserves (Chapter 171-3, HRS); and State parks (Chapter 184, HRS). As any "land" seaward of the shoreline (underwater) is classified as conservation district, all ocean energy projects anchored within 12 miles require a CDUA permit. Chapter 190D, HRS, Ocean and Submerged Lands Leasing, specifically addresses the procedures for issuing CDUA permits for OTEC project construction in State marine waters and submerged lands.

In addition, the Board of Land and Natural Resources also is granted authority under Chapter 171, HRS, Public Lands, Management and Disposition, to sell or lease public lands to government agencies or public utilities, and to grant licenses or easements for use of public lands. The board is not permitted to do so in cases where the public utility has suitable lands of its own. This could apply to public utility-sponsored OTEC projects requiring shoreline land parcels for plant construction.

In Chapter 266, HRS, the Legislature grants DOT authority to manage all ocean uses seaward of the shoreline, shore waters and navigable streams. Section 3 of that chapter specifies that DOT's jurisdiction pertinent to ocean energy projects, such as OTEC, includes: Licensing and registration of persons or organizations engaged in commercial activities in or on the shore waters or shores of the State; and licensing and regulation of equipment utilized for commercial activities in or on the shore waters or shores of the State. In practical terms, this means that any construction, dredging, or filling in or near shore requires a DOT Shorewaters Permit. This may be processed simultaneously with a CDUA permit. In cases where DOT does not concur with CDUA approval, it may request a separate Shorewaters Permit application.

DOH is directly responsible for maintaining environmental quality in general and that of State waters in particular, under Chapter 342, HRS. DOH defines State water quality standards and monitors compliance with Federal and State water quality standards. Because OTEC technology requires upwelling and discharge of deep seawater, development must abide by Federal and State water regulations.

The State Environmental Policy Act, Chapter 343, HRS, mandates procedures to identify and mitigate impacts on marine and coastal ecosystems, among others. Any agency action or development activity requiring a CDUA, an SMA permit, or a Federal permit triggers an environmental assessment. Environmental assessments determine whether the action or activity may generate significant environmental impacts. If the permit-granting agency concludes that impacts will be significant, the agency or organization submitting the application must prepare an environmental impact statement (EIS), which will be subject to public review. The Department of Health's Office of Environmental Quality Control acts as the clearinghouse for dissemination and archiving of completed EISs.

The production and sale of electricity from a commercial-scale OTEC plant, or any other commercial-scale ocean energy project, would require review by the Public Utilities Commission (PUC). PUC oversees, among other things, all persons or organizations involved in the "production, conveyance, transmission, delivery, or furnishing of light, power, heat, cold, water, gas, or oil" (Chapter 269-1, HRS). It is quite possible that commercial OTEC plants would furnish power, cold, and water. PUC reviews utility rate schedules to ensure that they are "just and reasonable."

Furthermore, PUC has the specific mandate (Chapter 269-27.2, HRS) to direct public utilities "to arrange for the acquisition of and to acquire electricity generated nonfossil fuel sources as is available...to maximize the reduction in consumption of fossil fuels in the generation of electricity." In the process of assuring that just and reasonable rates are charged for nonfossil fuel-generated electricity, PUC may set the rate paid by the public utility for electricity generated from alternative energy as not less than 100 percent of the cost the utility avoids by not having to produce the electricity itself. This particular regulation is in direct accord with the Federal utility regulations.

The Counties also have jurisdiction over OTEC and similar energy projects, through two statutes. The first, Chapter 46-19,HRS, grants Counties the power to develop alternative energy resources themselves in joint ventures with public utilities. The second is the State Coastal Zone Management Law (Chapter 205A, HRS). This law grants each County authority to define Special Management Areas (SMAs) extending from shoreline inland not less than 100 yards. Within the SMA, Counties manage a permit process that ensures that all developments conform to the objectives of the State Coastal Zone Management Law.

Permit applications must include a survey of the property and shoreline, description and plans for the project, and a description of the affected environment. If the project cost exceeds $65,000, a review for a major SMA permit is triggered. If the reviewing agency's environmental assessment determines that the project will have serious environmental impacts, a formal environmental impact statement is required. The permit-granting agencies are the planning commissions of each County, with the exception of the City and County of Honolulu, where the authority rests with the City Council.

Federal: The U.S. Army Corps of Engineers (COE) also has jurisdiction over waters and submerged lands from the shoreline three miles seaward. This authority stems from Federal legislation including, but not limited to, the Rivers and Harbors Act of 1899; National Environmental Policy Act of 1969; and Federal Coastal Zone Management Act of 1972 (P.L. No. 92-583). The Department of the Army permits cover construction in, under, or across navigable waters within the three-mile limit. These would apply to any land-based OTEC pipelines, or a moored, offshore OTEC facility.

The Public Utility Regulatory Act of 1978 (PURPA), requires electric utilities to buy electricity from qualifying facilities at the utility's "avoided cost." Thus PURPA both opened the market and established the price level for renewable power production.

The Federal Energy Regulatory Commission (FERC) has issued three notices of proposed rule-making under PURPA to more clearly define market access and pricing for independent power:

- Regulations Governing Independent Power Producers, 53 Federal Register 9327 (March 22, 1988), Docket No. RM88-4-000.
- Regulations Governing Bidding Programs, 53 Federal Register 9324 (March 22, 1988), Docket No. RM88-5-000.
- Administrative Determination of Full Avoided Costs, Sales of Power to Qualifying Facilities, and Interconnection Facilities, 53 Federal Register 9331 (March 22, 1988), Docket No. RM6-000.

These proposed regulations would streamline rate approval for independent power producers by local public utility commissions; authorize states to institute a program of competitive bidding to meet utility need for new generation capacity; establish new guidelines to determine avoided costs; and permit qualified facilities to build and own interconnection facilities.[8]

Electricity Transmission

State: In ordinary circumstances, projects such as the Hawaii Deep Water Cable (HDWC) would pass through the same permit process specified for OTEC projects. HDWC also would require County right-of-way and easement permit, as it would pass overland on the Big Island and Maui. However, the Legislature designed a unique, streamlined permit process specifically for the HDWC, codified as Title 12, Chapter 196D, HRS, Geothermal and Cable System Development. This statute cites the need "to develop a consolidated permit application and review process to provide for and facilitate the firm assurances that companies will require..." in order to complete a project requiring such heavy capital investment.

Thus, according to Section 6: all Federal and State agencies with permit-granting authority join in a single review process, and "...shall cooperate...to minimize duplication between and, where possible, promote consolidation of Federal and State requirements. ...this...shall include, among other things, joint environmental impact statements with concurrent public review and processing at both levels of government." This consolidated review is facilitated by DLNR.

Federal: As currently designed, the deepwater cable would cross out of State waters and into Federal jurisdiction. The Outer Continental Shelf Lands Act of 1953 affirms Federal jurisdiction and control over the subsoil and seabed of all submerged lands beyond the State's three-mile limit. Other Federal laws applicable to this project will be the Submerged Lands Act of 1953; Coastal Zone Management Act of 1972; Rivers and Harbors Appropriation Act of 1899; Federal Water Pollution Control Act; Marine Protection, Research, and Sanctuaries Act of 1972; National Environmental Policy Act of 1969; and Federal Power Act. Both the Law of the Sea Convention and the Continental Shelf Convention specifically grant states the rights to lay submarine cables on the marine bed. Most of these laws relate to COE's authority over construction in navigable waters.

Monitoring and Research

State

As has been pointed out, the Department of Health has primary responsibility for monitoring State environmental quality, especially with respect to ocean waters and ecosystems. The Office of Environmental Quality Control acts, to a limited extent, as a clearinghouse on environmental impact statements, updating other State agencies on new activities and projects, and their possible effects.

In addition to general ocean research performed by various departments and institutes within the University of Hawaii, the State has established three research organizations which conduct research on ocean energy resources and related topics. The Hawaii Natural Energy Institute (HNEI), created by Act 235, SLH 1974, is charged with research and development of alternative energy sources for Hawaii. Along with their involvement in OTEC development, HNEI staff also are responsible for the geothermal pilot well, photovoltaic energy development, and alternative transportation fuels research.

The Natural Energy Laboratory of Hawaii (NELH) was established primarily to further OTEC research. Section 26-18, HRS gives DBED the mandate for energy research, especially regarding ocean resources and control of NELH. The director of

DBED sits on the board of NELH, as does the chair of the Board of Land and Natural Resources. Chapter 227, HRS establishes NELH to "manage and operate research facilities [to] provide sites for research, development, demonstration, and commercialization of natural energy resources and other compatible scientific and technological investigations". As of July 1, 1990, the State consolidated NELH and the HOST Park into the Natural Energy Laboratory of Hawaii Authority. This restructuring is expected to enhance administrative and operational efficiency on site.

Finally, the Pacific International Center for High Technology Research (PICHTR) was established in 1983 by the Legislature (Chapter 304-65, HRS) as an educational and research institution with a mission to promote education, scientific, technological and literary pursuits in the areas of high technology, and to support high technology industry in Hawaii. In 1985, PICHTR was incorporated as a private, non-profit education and research corporation.

PICHTR has identified three technology research and development niches in which Hawaii has a comparative advantage: information technology, specifically focusing on undersea robotics research; energy and resources technology, specifically focusing on undersea robotics research, energy and ocean resources technology, specifically focusing on OTEC, geothermal, hybrids, integrated electric utility, wind, hydrogen and bioengineering.

In support of its efforts, PICHTR looks to the Federal and State governments and to foreign nations for funding support. It has successfully solicited major grants from the Government of Japan to develop OTEC technologies. PICHTR also solicits funding from the private sector.

Federal

The Federal government contributes directly to many of the research projects connected with these organizations. As an example, the Federal contribution to the Hawaii Deep Water Cable feasibility project totals more than $22 million. The State contributed only $5 million. Total Federal support for State energy projects outlined in the 1990 State Energy Functional Plan exceeds $23 million (although not all of the Federal grants outlined have been confirmed).

Federal legislation also supports involvement in ocean energy research. Recently, the Internal Revenue Service (IRS) was petitioned by GenOtec of Washington, D.C. and the State for tax credits to permit more rapid cost recovery for OTEC properties. The Internal Revenue Code was modified by the Energy Tax Act of 1978 and amended by the Crude Oil Windfall Profit Tax Act of 1980 to qualify OTEC property for energy tax credits. GenOtec applied for the credits in the Caribbean. The State applied for credits in Hawaii and the U.S. Trust Territories. Both GenOtec and the State were notified that their requests had been approved.

Infrastructure Development

State

Hawaii has three organizations devoted to commercial infrastructure development for ocean energy technologies and related activities. The High Technology Development Corporation (HTDC) is established by HRS 206M to develop projects and industrial parks encouraging commercial high technology ventures in Hawaii. In addition to pure research, PICHTR is mandated to "assist the State's high technology development corporation in its efforts, [by promoting] educational, scientific, technological, and literary pursuits in the area of high technology...".

The site of the Natural Energy Laboratory of Hawaii has been expanded to incorporate the Hawaii Ocean Sciences and Technology (HOST) industrial park. This venture was an initiative of HTDC. HOST provides the infrastructure for ongoing OTEC experiments, and for commercial aquaculture ventures made possible by OTEC's cold, nutrient-rich, deep seawater. The two organizations have been merged under DBED.

Federal

In 1980, the Federal Ocean Thermal Energy Conversion Act, PL 96-320 (later modified by PL 98-623) established licensing procedures and authorized loan guarantees for OTEC facilities; while PL 96-310 supports the commercial establishment of OTEC generating plants.

Education and Public Awareness

State

Legislation mandates that all State departments mentioned educate the public regarding their areas of responsibility. The directors of business, economic development and tourism, land and natural resources, transportation and health are all directed to organize public education programs, publish annual reports, and make all ongoing research available to the general public. Furthermore, each agency issuing permits requires public hearings as part of the process. Public hearings also are required to review environmental impact statements.

MANAGEMENT ISSUES[9]

During the late 1980s, oil prices were low. This condition has not endured. Indeed, if all externalized social and environmental costs were considered, the condition would not exist today. The use of fossil fuels carries a number of negative externalities: carbon dioxide and monoxide and sulphur dioxide are all airborne health hazards; carbon dioxide contributes to global warming; ocean transport of petroleum and its products risks ocean health; the number of cars steadily increases and so does the amount of land devoted to roads; etc. Ocean energy technologies could provide the State with comparatively clean, renewable energy.

But in Hawaii, it will be some time before the ocean plays a significant role in the State's energy supply. Overall, a research and development strategy that actively explores all alternative energy sources, coupled with enthusiastic campaigns for conservation, energy efficiency, and recycling, will work to ensure reduced dependence on oil. The State Energy Functional Plan maps out just such an approach. With regard to ocean energy, this would mean balancing the heavy investment in OTEC development with appropriate support for such technologies as wave energy research as well.

Development of ocean energy resources, and the State's energy sector generally, faces five major issues: site and use conflicts; environmental impacts; inadequate coordination of data acquisition, consolidation and dissemination; overlapping jurisdictions and authorities; and limited funds, labor and equipment.

Site and Use Conflicts

Existing electrical generation plants have two major negative impacts on residents use of the shoreline and ocean. They disrupt viewplanes within the coastal area. A particularly good example of this is the HECO Kahe Point plant overlooking Ko Olina. In addition, residents have expressed concern regarding the possible effects of effluent discharge and thermal pollution. These latter two disrupt offshore fishing grounds.

Some people have complained that shore-based commercial-scale OTEC plants will disrupt prime surfing locales. New slant drilling techniques will ameliorate this problem by burying seawater pipes beneath the shoreline on their way out to sea, but the impacts of this need clarification. Environmentalists and marine mammal devotees suggest that the deep water cable will conflict with the use of that ocean space by whales, dolphins and sharks, and that electromagnetic frequency leakage generated by the cable will disrupt the animals' breeding and feeding grounds. For the most part, however, ocean energy issues have generated little controversy at public meetings, due perhaps to insufficient information.

In order to diversify Hawaii's energy sector, the State will ask residents to judge the trade-offs involved in adopting one source of energy over another, and decide which they prefer. To do this, people will need to understand these energy projects in immediate terms. They will require the kind of information that makes it possible for them to envision a project's impact on their day-to-day ocean activities. Because people know little about how OTEC works, or about the potential for wave energy generators or marine biomass plantations, use conflicts exist primarily in theory.

Few studies, for example, convey to the public any sense of how much a shore-based, commercial-scale OTEC plant could disrupt the local marine environment and disturb other commercial or recreational activities nearby. An offshore OTEC plant would act much like an artificial reef, and would affect fishing in its vicinity. Wave generation plants can be large-scale constructions, stretching great distances through ocean waters. Such plants would constrain any ocean transport and certainly some ocean recreational activities, and possibly fishing as well. However, these plants can also be shore-based, or designed to serve as ocean breakwaters. Marine biomass plantations constitute by their very nature a massive disruption of normal marine ecosystems.

It is certain that commercial-scale development of any ocean energy resource will generate use conflicts. There are few mechanisms to negotiate those conflicts, or compensate communities for use sacrifices they may be forced to accept "for the common good." In fact, courts provide the only recourse. While case law offers numerous examples of compensation for loss of coastal property, it has few regarding compensation for loss of coastal use.

Environmental Impacts of Energy Facilities

Energy Production

The possible environmental and social trade-offs in ocean energy development need quantification. The public recognizes, and wishes the State to recognize, that each type of energy production has quantifiable economic and environmental impacts. Therefore, Hawaii, like New York and California, should include in its energy planning process the explicit comparison of costs and benefits of renewable energy alternatives with conventional energy (e.g., fossil fuel, coal, nuclear).

For example, the long-term benefit of a plentiful supply of drinking water could be compared with the short-term impact of construction activities to build the OTEC plant and seawater system. Platforms and underwater subsystems are artificial reefs, attracting fish and other species, a positive impact; but intake pipes may redistribute ocean nutrients, a potential environmental cost.

Even within technologies, there may be more beneficial alternatives. For example, open-cycle OTEC, with ocean water as its working fluid, could be compared with the closed-cycle plant with its potentially hazardous working fluid of ammonia or Freon.

Finally, consideration could be given to comparing the costs of outgassing of dissolved carbon dioxide into the environment of conventional and OTEC power plants. Recent experiments have shown that the carbon dioxide release from a fossil-fueled power plant of comparable size is 15 to 25 times larger than that of an OTEC plant.

Public concerns echo these forecasted impacts. At public meetings, people wanted to know more about the potential impacts on the marine environment due to large commercial seawater discharge flows from OTEC and related mariculture developments, including positive aspects of "seawater return." In addition, people felt that they had insufficient information on several issues: the severity of thermal pollution from OTEC plants; potential impact to the marine environment and marine biota resulting from the proposed deepwater cable; potential impact of the undersea cable on the natural area reserve on Maui; and effects of pollution on marine mammals caused by ocean energy activity.

Inadequate Data Coordination

Many ocean-related Federal and State agencies are collecting and compiling data on the coastal and ocean environment. These data are useful as a historical record indicating environmental trends, providing baseline information with which to assess the impact of development activities, and as a foundation for establishing a fiscal evaluation of both the tangible and intangible characteristics of the State's marine environment.

Currently, this information is scattered throughout the files and libraries of those diverse agencies. It would increase the efficiency and effectiveness of ocean energy development specifically and ocean management generally if a central clearinghouse existed to organize and update such data. Furthermore, an inventory of work done to date will reveal areas that require greater research. This will be particularly critical in establishing the extent of destruction and environmental degradation in the aftermath of oil spills, when the State will want to define liabilities.

Public meetings also revealed that the public perceives a lack of reliable data on environmental impacts. This may indicate that the available information is not being effectively disseminated. At least one person commented that even though he was interested in reports on coastal environment impacts, he found the language of the technical reports daunting. A more straightforward, vividly worded summary of impact assessments might be an answer to this problem. This is a critical information need, to ensure meaningful public participation in permit hearings and environmental impact assessments, as well as the overall planning process.

Overlapping Jurisdictions and Authorities

Sites, Development Permits and Plans

Diversifying Hawaii's energy sector will require the development of large-scale projects, whether based on conventional energy, or renewable energy. Existing Hawaii statutes will impose conditions on those development plans in order to mitigate adverse environmental impacts. People will no doubt raise additional objections or questions as they learn about each new project. Thus the relevant State agencies have two tasks in regulating ocean energy developments: incorporating public opinion regarding costs and benefits to the community, and expediting the development of a needed resource after it has earned public approval. The existing system of zoning, permit-granting and conducting environmental reviews can be problematic on both fronts.

As many as five agencies exercise authority over the State's shores and nearshore waters. This results in duplication of efforts and public confusion over administrative and regulatory accountability. Some beneficial side effects do emerge from the multiplication of jurisdictions and permit requirements: project development is slowed sufficiently to allow public consideration and debate, and opposition is mustered to question expert opinions. If, however, those are judged to be positive, they should be explicitly and formally institutionalized into the planning and permit process, and actively and aggressively sought.

The lack of public awareness about the public planning and management process for ocean energy resources can be fatal to the process. Public meetings conducted by the Ocean and Marine Resources Council in June 1990 revealed disaffection and frustration with what people perceived as fragmented and confusing bureaucracies that seem to excel at referring complaints elsewhere. While political despair may distort this view, it nonetheless indicates that people want to participate in decision-making but cannot figure out how. Not only do people perceive the system of public hearings as difficult to track, they feel that opinions expressed at them have no effect on the end results of planning, and in any case no one reports results back to the community. The need exists for a concentrated and neighborly oceans outreach program. Such a program should include the means for communities to develop common goals and visions for integrated ocean use, and meet community needs, such as secure energy supplies.

Limited Funds, Labor and Equipment

Supporting in-depth research on the full range of potential ocean energy technologies will require greater levels of funding. In the 1980s, Federal funding was reduced from $841 million annually to a low of $4.2 million. Although availability of Federal, international, and private sector funds has increased in the last few years, an aggressive, creative approach to research fundraising and solicitation of venture capital would speed appropriate ocean energy development. Both pure and applied research on ocean energy inventories, applicability of other ocean energy technologies, and the coastal and marine environment will be needed before the State decides on either the optimal use of its ocean resources, or the optimal structure of its energy supplies.

Most State agencies also lack staff resources to devote at least one person at each branch level to community outreach, education, and relations. Yet that is a critical need, particularly given the complexity of ocean energy development, which is equalled by the complexity of the regulatory system that exists to administer the coast and oceans. State agencies would be aided greatly by additional staff charged entirely with fielding community questions, composing information modules on ocean resources, and compiling integrated ocean environmental databases. With regard to ocean energy outreach, DBED could institute joint programs with other government agencies, and with the utility companies and research organizations to support school science projects, solicit participation on possibilities and plans to community interest groups, and inform the local business community on prospects and opportunities in ocean energy development

Finally, optimizing Hawaii's use of ocean energy resources, and ocean resources overall, requires long-term thinking, foresight, monitoring of emerging trends and technological innovations, and design of visions that capture the community's preferences for its daily interactions with the ocean as a whole.

This in itself calls for a research and planning team focused on scanning technical literature for the emergence of innovative technologies, composing alternative scenarios for ocean energy development and its possible byproducts, and organizing workshops to allow the public to participate in designing and reviewing those alternative development scenarios. The goal should be ocean energy development based on the community's needs and environmental preferences. This deserves the investment of funds and staff.

RECOMMENDATIONS

Objective

Balance optimal, cost-effective development of the State's ocean energy resources, as well as the State's other energy sources, with the preservation of Hawaii's coastal and marine environments.

Policy A

Actively encourage alternative ocean energy use as well as the development of integrated energy resources and the use of hydrogen as a medium of energy transfer, as an alternative to fossil fuel dependence.

Implementing Actions:

DBED should:

1. Support establishment of a commercial-scale OTEC plant at the earliest possible date.

2. Expand funding support to ocean energy research and development, including but not limited to OTEC, wave energy capture, marine biomass, and the exploration of ocean energy innovations.

Policy B

Conduct an inventory of Hawaii's ocean energy resources and the coastal and marine environments that their development affects.

Implementing Actions:

DBED, in cooperation with OSP, should:

1. Design a coastal and marine environmental database, in conjunction with other related agencies, to consolidate government, university, and private research, which would be updated continuously and publicly accessible.

2. Update ocean energy resource inventories completed to date, and expand them where necessary to include data on wave, tidal, marine biomass, salinity gradient, or other prospective energy resources.

3. Assess the relative degree of impact on the marine and coastal environment of the complete array of potential energy sources available for State use, in order to establish a cost/benefits matrix for public consideration.

4. Identify shore areas most at risk from potential oil spills, inventory their plant and animal life, and evaluate the magnitude of potential financial loss of both tangible and intangible resources in those areas at risk. [See Waste Management section.]

Policy C

Increase public knowledge regarding ocean energy technologies.

Implementing Actions:

DBED, in cooperation with DOE, should:

1. Solicit Federal and private-sector funds to expand its educational campaign on ocean energy resources for use in schools, including information on relevant ocean-related State and County programs.

2. Develop informative, multimedia presentations for public dissemination on different ocean energy technologies.

DBED should:

3. Update financial and investment data on ocean energy technologies developed elsewhere, as background information for potential commercial ocean energy private-public partnerships.

4. Research or model the costs of electricity production and potential co-products for all potential ocean energy sources.

Policy D

Mediate conflicts of use between ocean energy programs and other ocean uses, and compensate communities of interest when other uses are limited or curtailed by State-mandated ocean energy activities.

Implementing Actions:

DBED should:

1. Establish a program offering facilitated negotiation on ocean energy-related conflicts.

2. As a means to preempt potential conflicts, investigate innovative approaches to facilitate goal-setting within Hawaii's communities with regard to energy development and ocean management, such that agreed-upon goals could be incorporated into an ongoing ocean planning process.

3. Investigate means to compensate communities for loss of coastal and ocean use due to ocean energy developments, and to establish rates and kinds of compensation.

Policy E

Enhance coordination and cooperation among State, County, and Federal agencies responsible for permitting ocean energy activities, to reduce duplication of effort, simplify the permitting process and increase public involvement in ocean energy management.

Implementing Actions:

DBED, in cooperation with DLNR and DOT, should:

1. Develop means to increase the opportunities for public notification and review of proposed projects, including instituting a public hearing explaining the project and inviting comments at the time the application for permit is first filed.

2. Evaluate the Federal, State, and County regulatory regimes applicable to energy activities and suggest approaches to coordinating the permitting process.

NOTES

1. This section owes much to the draft *Hawaii State Functional Plan: Energy*, particularly pages 6-8, and the *State of Hawaii Databook: 1989*.

2. The Btu equivalent of barrel of oil will vary depending upon its quality, but an "average" barrel of oil is equivalent to approximately 6 million Btus.

3. The following section draws heavily on data presented in the *State Energy Resource Coordinator's Annual Report: July 1, 1988 - June 30, 1989*, particularly pages 5, and 96-99.

4. Salinity gradient power derives from the osmotic pressure difference between fresh and saltwater. The world's resources of this power generally lie where large freshwater streams meet either the ocean or landlocked saline lakes such as the Dead Sea. The power potential is greater in the latter instance, due to higher salinity. Hawaii simply lacks any major instance of this freshwater-saltwater interface.

5. At the time this site was developed, NELHA was the Natural Energy Laboratory of Hawaii (NELH). As of July 1, 1990, NELH merged with the Hawaii Ocean Science and Technology (HOST) Park, forming the Natural Energy Laboratory of Hawaii Authority. Increasing overlaps between the two agencies in terms of infrastructure, operations, and services suggested consolidation for administrative efficiency. Like its parent organizations, the new organization is administratively attached to DBED.

6. The Natural Energy Laboratory of Hawaii Authority also manages the State's experimental geothermal power plant, the Puna Geothermal Facility, which includes the HGP-A geothermal well, the 3 MW wellhead generator plant, and Noii O Puna, the Puna Research Center.

7. This section derives much of its information from the monograph by Sumida and Hills on legal, institutional and financial aspects of the deepwater cable project, with updates elicited from the State Energy Resource Coordinator's report for fiscal year 1988-1989.

8. This section on PURPA and proposed corollary regulations was drawn from Edwin T.C. Ing, President, American Wind Energy Association, "Regulatory and Legal Issues," presented at the "Enhancing Renewable Energy Development in Hawaii Workshop," sponsored by the State of Hawaii, Department of Business and Economic Development, Energy Division, July 26 & 27, 1989, in Honolulu, Hawaii.

9. Most of the issues presented in this section are drawn from public meetings sponsored by the Ocean and Marine Resources Council during June, 1990, and from the "Workshop on Enhancing Renewable Energy Development in Hawaii," sponsored by DBED in July, 1989.

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MARINE MINERALS

THE RESOURCE

Hawaii is developing strategies to develop its ocean resources for diversifying its economic base. Mineral deposits, ranging from sand to cobalt-rich manganese crusts, are resources found within Hawaii's territorial sea and Exclusive Economic Zone (EEZ). The mineral deposits in the Hawaiian EEZ merit investigation in the light of future projections indicating that 25 percent of the world's mineral supply will ultimately be derived by ocean mining (Waihee 1990). The marine mineral resources of the EEZ could be an important part of Hawaii's economic future.

In an effort to diversify its economy, provide jobs and develop new marine industry, Hawaii actively has considered ocean mining since 1972 (DOI 1990). Such an industry would provide an economic boost that would carry beyond the initial mining endeavor to new spin-off industries, such as marine research, exploration electronics, submersibles, marine engineering and technology-transfer opportunities for an international market. The potential to develop a marine minerals industry is being considered both for offshore manganese resources as well as nearshore sand/limestone resources.

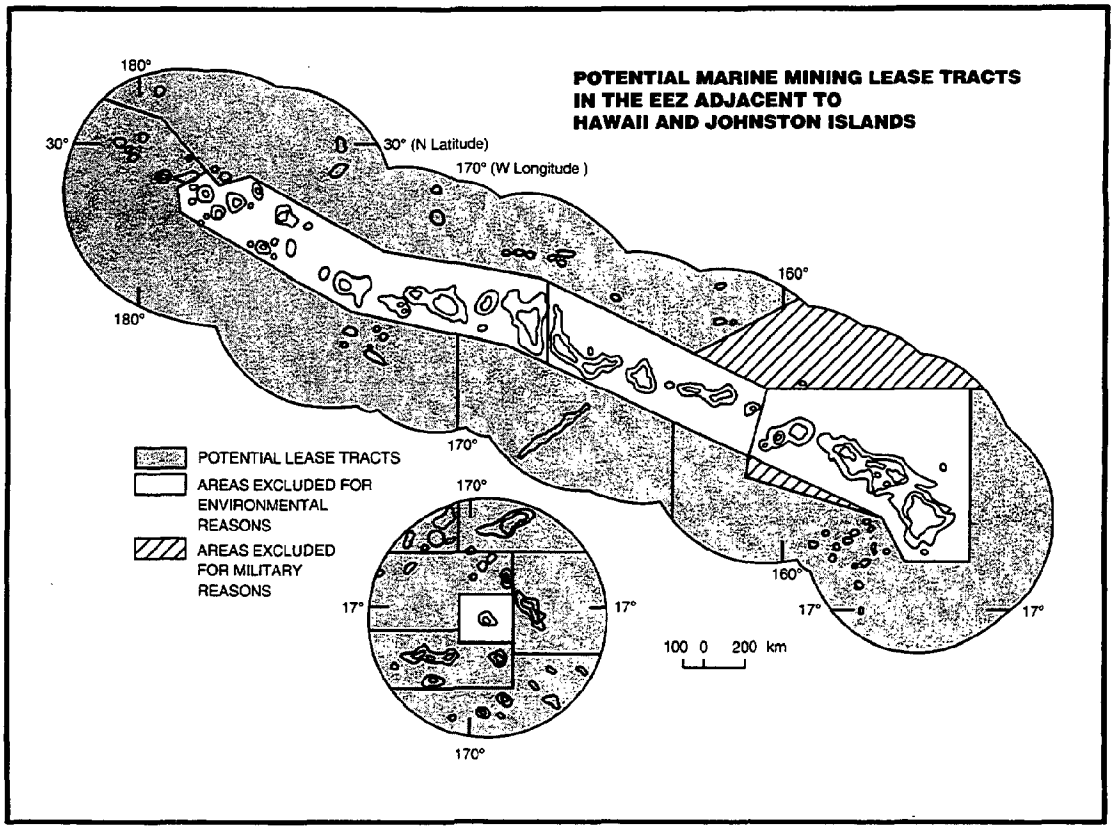
Offshore Resources

The most valuable offshore marine minerals resources are cobalt-rich manganese crusts and manganese nodules.

Location and Value

Manganese deposits contain varying combinations and percentages of metals such as iron, manganese, cobalt, copper, nickel and platinum, with cobalt being by far the most economically valuable. Cobalt-rich manganese crusts, associated primarily with seamounts and guyots over areas sufficiently large enough to support possible ocean mining ventures, are found within the EEZ adjacent to Hawaii and Johnston Island (See figure on page 108). The best resources are located at depths between 800 and 2,400 meters (DOI 1990).

Manganese nodules, which are relatively rich in manganese, cobalt, iron, nickel, and copper, are abundant over vast areas of the deep seabed at depths of 4,000-5,000 meters. Nodules are usually potato-shaped, three to six cm in diameter, and lie



scattered on the ocean floor. Crusts occur as thin blankets and encrustations on sediment-free areas of the seafloor and seamounts. They range from thin films to thicknesses of more than ten centimeters. It is not known presently which of these deposit types will be first to provide commercial minerals for U.S. or international markets. Hundreds of millions of dollars already have been committed to the exploration and technology development by industry and several national governments for deep seabed nodules. Present knowledge concerning the crust deposits is very preliminary. Nevertheless, several factors related to the crust deposits warrant continued efforts to learn more about them. Crusts are different than nodules in a number of ways (Johnson and Clark 1988).

First, cobalt concentrations in crusts are four times those of nodules, contain a higher total value of metals than nodules, and have a much higher value per square meter in place. Some crusts also contain potentially economic grades of platinum. Recent studies show that the crusts may carry up to $350/ton of contained metals, whereas nodules may carry only about $200/ton (Wiltshire 1990a). Of these metals, cobalt is one of the most critical in supply because domestic reserves are inadequate and cobalt is of strategic importance to the United States. The United States accounts for about one-third of the world's consumption of cobalt, yet produces none of it (five percent is recycled). Its special properties are ideal for producing powerful permanent magnets and corrosion and high temperature resistant super-alloys. In addition, crust metals act as catalysts for a variety of chemical processes and are important to the nation's industries.

Second, rich crust deposits are located at shallower depths and in closer proximity to potential operation bases than nodules. The water depths of optimum crust deposits vary from 800 to 2,400 meters and crusts are much more accessible than the 4,000-5,000-meter-deep nodule fields. For example, shallow depths present fewer handling problems in raising mined ores to the surface (Wiltshire 1990a). In addition, the closer proximity of potential mining enterprises to centers of commerce likely would result in lower costs for supplies, transportation and repairs for a crust mining operation.

Third, existence of manganese crusts within the legal regime of a domestic EEZ may facilitate development of a marine minerals industry. The richest-known nodule deposits, on the other hand, are on the deep seabed outside the EEZ, an area of disputed jurisdiction. A more attractive regime for mining manganese crusts likely would occur within the EEZ of Hawaii.

A marine minerals industry in Hawaii potentially would offer the United States a domestic source of important strategic materials. Currently, over 95 percent of the cobalt used in the United States is imported. A domestic source of strategic marine minerals could alleviate the problem of dependence on foreign importation of such strategic minerals. Cobalt, manganese and platinum —metals critical to U.S. industry — are imported from countries with unstable political conditions or where other supply disruptions could occur for geopolitical reasons, e.g., South Africa, Zaire and Zambia. Of the principal mineral resources found in the EEZ (crusts, polymetallic sulphides and nodules) the United States imports the following:

TABLE 1

METALS OF U.S. CONSUMPTION IMPORTED

Manganese	99%
Cobalt	95%
Platinum	92%
Nickel	74%
Zinc	67%
Cadmium	66%

Source: Adapted from "Advanced Technology and Science: A Key to Oceanic Development" (1987) MTS Journal, Vol. 22(1)

An additional political dimension for the United States to consider is the possibility that the first crust mining operation in the sea may be the only one to be developed anywhere as the investment costs are so high and the available sites so few. Foreign producers, including State-owned or State-controlled companies, are likely to continue to be the measure of competition that must be met by both domestic onshore and offshore producers (U.S. Congress 1987). The cobalt market is a limited one. Should it aggressively pursue mining exploration and development, the United States could preclude other entries in the market, thereby securing a domestic source of a strategic mineral in an unstable and limited world market.

A recent study estimates that offshore crust mining, combined with onshore processing in Hawaii, would generate annual sales of about $540 million statewide and lead directly and indirectly to more than 3,000 new jobs (Morgan 1990). About half of these sales and jobs would be generated in the State if only mining occurred and the ore were transported elsewhere for processing. Such an industry in Hawaii, with or without processing, would diversify the economy and increase commerce independent of tourism, government and the construction industry.

Nearshore Resources

Sand is the most valuable nearshore marine mineral. As one of the seemingly unlimited products of the sea, it is of vital importance to everyone in Hawaii, residents and visitors alike. As such, sand mining may be the marine mineral to come under development in the State in the near-term. The worth of Hawaii's beaches as a recreational focus for residents and visitors goes beyond any dollar value. Millions of visitors (6.6 million in 1989) journey to Hawaii, drawn in large part by the beauty of the beaches. Several of the State's most popular beaches, including Waikiki and Ala Moana, are sustained by man or are influenced by the activities of human beings. These areas have histories of net erosion and sand loss (Dollar 1979). Beaches, especially man-made ones, must periodically be replenished with quantities of clean, white beach sand. Maintenance of white sandy beaches, coupled with the potential need to compensate beaches for rising sea levels, provides impetus to the State to investigate the feasibility of mining nearshore sand resources to meet these pressing needs.

Location and Type

Sand for beach enhancement and construction comes from a variety of sources. Materials for concrete are made with crushed limestone deposits from raised reefs or lithified dunes, crushed basalt from quarries, or crushed dredge spoils. Sand for other construction needs comes from inactive dunes or beach ridges (inland), or is imported silica sand from Australia or Canada. Imported sand, (approximately 100,000 tons a year), at $65 - $95 per ton, is reserved for specialized uses, such as tournament-quality golf courses or high-quality Portland cement.

While crushed basalt and limestone aggregate may be acceptable (though expensive) for the construction industry, they are not acceptable for beach replenishment. Basalt is too dark in color and limestone hardens over time, eventually leaving a beach denuded of sand. Crushed rock is angular and uncomfortable to walk and lie on. It contains adhering rock powder which washes out into nearshore waters, creating turbid water and smothering coral reefs. Crushed quarry sand (lithified sand dunes) and inactive inland dunes serve as the primary source of sand for State as well as County beaches. Sand for beach replenishment is obtained from graded onshore, inland sand dunes located on Kauai, Maui and Oahu. Inland sand dunes on Oahu are expected to be depleted within ten years (Griffin 1990). Importing sand from the Neighbor Islands is very expensive to meet the needs of Oahu's recreational beaches.

All of the previously described terrestrial, natural sand sources are of very limited quantity, rapidly dwindling, or production cost-prohibitive. Dwindling onshore reserves and restrictive State legislation and administrative rules have prohibited the harvesting of sand deposits. Concern for future shortfalls of sand supplies have prompted studies to prospect for offshore deposits (Coulbourn et al 1988).

While large deposits of sand with the requisite grain size, distribution and color suitable for beach replenishment occur at a number of sites nearshore, they have not yet been used for this purpose. "Nearshore" is here defined to mean within three miles of the shoreline. Geophysical and geological research completed during the last 20 years has identified several deposit sites, which appear to be the most likely candidates for supplying beach sand for Oahu beaches (Cruickshank 1990).

The economic and technical feasibility of offshore sand recovery depends to a great extent upon the size and location of the particular deposit to be mined. The size (volume) of the deposit determines, in part, how profitable the venture will be. For a large deposit, the expense of deploying dredge equipment and possible delivery pipe could likely be offset by volume of production (Casciano and Palmer 1969). Some sites are excellent in volume and proximity to the shore. It is estimated, for example, that approximately six million cubic yards of sand occur off the Reef Runway at Honolulu Interna-

tional Airport (Griffin 1990). Proximity to the beaches reduces transportation and other costs for needed replenishment endeavors.

RESOURCE MANAGEMENT

Federal Authority

Offshore Resources

Most minerals of economic interest, while within the 200-mile EEZ, lie in waters beyond the State's territorial sea. By Presidential Proclamation (1983), the United States claimed sovereign rights and jurisdiction for exploring, conserving and managing the natural resources within the EEZ, 200 nautical miles seaward of the coast. The primary purpose for establishing the EEZ was to bring mineral deposits within this area under U.S. control (Saiki 1990).

While the U.S. Congress has not yet enacted comprehensive legislation to implement the EEZ Proclamation, certain resource-specific laws essentially cover the same area of the EEZ. The Federal Outer Continental Shelf Lands Act (OCSLA), for example, is the domestic law covering the exploration and development of oil and gas reserves from an area similar but not identical to the EEZ.

Under the OCSLA, the U.S. Department of the Interior Minerals Management Service (MMS) controls mineral mining activities on the outer continental shelf. The MMS Office of Strategic and International Minerals (OSIM) develops policy and implements a program to promote the exploration, development and recovery of hard minerals. OSIM provides overall programmatic direction for offshore hard minerals activities and facilitates coordination among headquarters and its regional offices, adjacent coastal states, local governments and the public sector.

Although MMS has primary authority over marine mining activities in the EEZ, NOAA, National Marine Fisheries Service (NMFS), and the eight regional fisheries councils, play important consultative roles. In addition, the U.S. Army Corps of Engineers (COE) is responsible for granting permits for harbor facilities to accommodate ocean mineral processing, transportation or other services. The U.S. Environmental Protection Agency (EPA) has jurisdiction over water quality and benthos protection beyond the State's territorial sea limit.

Nearshore Resources

Nearshore sand deposits lie entirely within the State's marine jurisdiction, but the State must comply with specific Federal regulations. The NOAA Office of Ocean and Coastal Resource Management administers the Coastal Zone Management (CZM) Act of 1972, which was enacted primarily to provide assistance to States in developing programs for the management of lands and resources within the coastal zone.

For activities that occur within the navigable waters of the United States (from the mean high water mark seaward to the extent of the U.S. territorial sea), COE must be consulted. If dredging or discharge activities occur within the three-mile limit, a COE permit is required under the Rivers and Harbors Act. In addition, under the Federal Marine Protection, Research and Sanctuaries Act, a permit is required from the COE for the transportation of dredged material for the purpose of dumping within the navigable waters. COE also issues a permit under Section 404 of the Clean Water Act for placement of dredged or fill materials.

State Authority

Offshore Resources

In early 1984, in anticipation of proposed exploratory lease sales in Hawaii's EEZ, MMS and the State established a joint Federal/State Manganese Crust Task Force composed of Federal and State agencies and technical experts. The Task Force is co-chaired by the State Department of Business, Economic Development and Tourism (DBED) and MMS. Staffing was provided by DBED. The Task Force was assigned to oversee preparation of an environmental impact statement (EIS) and associated research for the proposed exploratory lease sale and to act as a forum for the ongoing consideration of ocean mining issues.

The work of the Task Force led to a joint Federal-State cooperative agreement for Marine Minerals Joint Planning and Review signed in December 1988. This Joint Planning Arrangement (JPA) gives Hawaii an active role in planning and reviewing offshore mineral development activities and coordinating program and policy issues of mutual interest. The JPA includes two committees: the Cooperative Steering Committee (CSC) and the Coordination Committee (CC). Both Committees are co-chaired by DBED and MMS and staffed by DBED. The CC is responsible for working with citizen groups, Federal and State decision-makers on planning, program and policy issues; coordinating project activities; and providing technical support to CSC. The JPA, a landmark agreement that creates a unique Federal-State partnership in managing offshore mineral resources, serves as the prototype for joint Federal/State EEZ management efforts.

The final EIS was released in October 1990. The Department of Interior is considering preparing a Secretarial Issue Document (SID) to analyze the EIS. The SID will recommend whether, when, and under what conditions to hold a marine minerals lease sale. From the beginning of the the SID process through a lease sale and the exploration phase, it will probably take at least 15 to 20 years before any mining occurs, given the discovery of mineable deposits.

The lead agency for the State's coastal zone management program is the Office of State Planning (OSP). The Hawaii CZM Program, a Federally approved program, began in 1977 to carry out the goals and objectives of the national CZM Act of 1972, as amended. The CZM Act requires that Federal activities and development projects directly affecting a state's coastal zone be consistent with approved state coastal programs "to the

maximum extent practical" (15 CFR 930.32). This "consistency" provision has been particularly effective for reviewing Federal activities that would not otherwise be subject to State laws and policies. Presently, OCS lease sales and leasing activities, are not subject to Federal consistency. In the leasing regulations, MMS stated that "coastal zone consistency concurrence is not required prior to a lease sale of OCS minerals" (54 Federal Register, pp. 2042, 2046, Jan. 18, 1989). However, all Federal activities, including OCS leases, are subject to Federal consistency requirements if they affect natural resources, land uses or water uses in the coastal zone. Support activities, such as transportation, storage or processing of recovered minerals, would occur within the state coastal zone and be subject to state program permits and other requirements (DOI 1990).

Other State agencies that potentially would be involved if an ore processing facility were to be established in Hawaii would include the Departments of Transportation (DOT), Health (DOH), and Land and Natural Resources (DLNR). Development activity within State waters requires a written permit from DLNR as well as other appropriate permits from DOT. DOT has authority within State waters and over activities at State harbor facilities. DOH is primarily responsible for pollution control, to include maintaining an ambient water quality monitoring program to determine water quality trends and comply with Federal and State regulations. In addition, DOH issues operating permits for industries that discharge wastewater into coastal waters of the State.

Nearshore Resources

The Hawaii CZM Program sets basic State policy to guide State agencies and County governments in all actions affecting the State's coastal zone. Hawaii's coastal zone includes the waters from the shoreline to the seaward limit of the State's jurisdiction and all lands excluding those lands designated as State forest reserves (Chapter 205A, HRS). In addition, on the landward side of the coastal zone, two "belts" circling the Islands — the Special Management Area and the Shoreline Setback Area — are established for more intensive management by the four Counties (OSP 1990). Activities involving sand mining would come under the purview of CZM, DLNR and County governments.

Sand mining has been effectively banned since 1978. The mining or taking of sand seaward of the shoreline is prohibited with some exceptions; including permitted replenishment or protection of public lands (Chapter 171-58.5, HRS), or where the mining or taking is authorized by a variance (Chapter 205A-44, HRS).

All land is designated at the State level into one of four use classifications (conservation, agricultural, rural or urban). All State waters are classified within the conservation district. The State retains control over all land classifications except urban, which is under County jurisdiction. If sand mining were to occur on conservation district use lands, which could include submerged lands, DLNR would retain jurisdiction and issue permits through a Conservation District Use Application (CDUA) process. In addition to a CDUA, an Environmental Assessment would be required. If the CDUA was for commercial purposes, a public hearing would be held.

Ocean dredging or sand recovery projects in nearshore waters within three miles of the mean high water mark would necessitate an application to determine whether a DOT permit was required. DOH establishes and enforces environmental quality standards for State waters.

County Authority

Offshore/Nearshore Resources

The Counties would be involved in land-based activities and developments associated with offshore activities that have direct impact upon the use of local infrastructure within State urban land-use districts. Under Hawaii's CZM program management, permits for activities within the shoreline area of the coastal zone are administered by County governments.

All four Counties have General Plans, some form of development plans, and zoning and subdivision ordinances. These Plans encompass the whole County, and lay out general objectives and polices for directing growth and development. The Counties share direct land-use control within State urban land-use districts and partial control within State agricultural districts.

County authorities would primarily include the parks and recreation departments for beach replenishment and the planning departments (Department of Land Utilization, City and County of Honolulu) under the Special Management Area (SMA) and the Shoreline Setback Area provisions of Hawaii's CZM Program.

SMAs and Shoreline Setback Areas were created by the Legislature to provide added controls on activities in shoreline areas. The SMA system is the permit process for County implementation of coastal zone management objectives and policies. Each County has devised its own rules and system following State guidelines.

MANAGEMENT ISSUES

Revenue Sharing

Offshore Resources

The U.S. Department of the Interior and Congress have long debated whether the OCSLA provides a sufficient basis for regulating the exploration and development of hard mineral resources of the U.S. EEZ. Several shortcomings limit OCSLA's suitability for managing hard minerals:

1. The OCSLA is primarily designed to meet the needs of the offshore oil and gas industry, not the needs of a potential marine minerals industry. The extensive regulatory guidelines and procedures for OCS oil and gas development do not exist for hard minerals mining. Section 8(k) of OCSLA gives discretion to the Secretary of the Interior, thus there are no assurances

to the mining industry that a stable, predictable leasing program will be maintained by subsequent administrations. Bonus bid competitive leasing requirements (money paid to the government before exploration or development begins) set forth in Section 7(k) of the OCSLA are not well suited for stimulating exploration and development of seabed hard minerals by the private sector.

2. The economic investment necessary to successfully explore and develop a hard minerals industry requires a public-private partnership. Private industry will need leases of submerged areas for this purpose. The only existing law that could allow a leasing process is the OCSLA. One major constraint, however, is that all revenue from a mining venture must be deposited in the national treasury. Under the OCSLA, the Federal government cannot grant revenue sharing. Until suitable mining legislation is enacted to provide for revenue sharing, there is little prospect that industry will substantially invest in expensive minerals exploration and development (Wiltshire, 1990b). Because of these OCSLA limitations, representatives from coastal states, the U.S. mining industry and environmental special interest groups have been working together for several years to develop a new legal regime to encourage the development of commercially successful and environmentally acceptable marine mining in the EEZ. To date, these efforts have not resulted in specific legislation which can survive the gauntlet of the Federal legislative process. However, the American Mining Congress and the Oceanic Society have provided joint testimony in support of the major provisions of existing draft legislation (Jones Bill, H.R. 2440). Continued efforts on the part of the State are needed to ensure that the final law to emerge from this process does indeed foster such development.

Federal-State Relations

Offshore Resources

Federal-State conflicts over offshore oil and gas leasing and development activities on the U.S. Mainland offer valuable lessons in how to avoid the problems that can arise when Federal and State agendas differ and the Federal government pays only lip service to State concerns. More effective partnership arrangements, such as those represented by the Manganese Crust Task Force and JPA, need to be ensured by legislation. Although the Task Force option is encouraged in MMS mineral mining regulations, no legislation or regulation mandates such cooperation, making these arrangements more tenuous than is desired.

Among the State's objectives for a marine minerals industry is the pursuit of a legal framework that assures the State's continued involvement and participation in the development and management of hard mineral resources in the EEZ adjacent to Hawaii. The State believes that such exploratory and development activities will cause significant impacts on the interests and rights of its citizens. Accordingly, the State will seek new regulatory or, if necessary, statutory arrangements to give Hawaii an assured voice in joint management of marine minerals resources.

Technology and Research Activities

The development of Hawaii as a marine minerals center requires that industries are made aware of the technological and research capabilities and concomitant opportunities available.

Technology

Opportunities for development of a marine minerals industry hinge upon jurisdictional concerns and constraints imposed by the present limits of marine technology. In some cases, the technology for development is state-of-the-art, while in others, it is no better developed than technology for mining on the Moon (UH 1988).

Technological and environmental systems development (systems for exploration, mining, mineral extraction, environmental mitigation and protection) are at various levels of development. The goal of mineral exploration is to locate, identify and quantify mineral deposits for potential commercial exploitation. Detailed sampling of promising sites is necessary to assess the commercial value of these deposits.

While the immediate challenge is to gain a better understanding of the physiography and geology of the seafloor and its environment, and to inventory minerals occurrence, the potential value of developing and marketing technology for seabed mining and processing systems should not and cannot be ignored. The exploration tools, mining system components, system optimization processes and associated waste management techniques, all require technology for ocean mining. For sand mining, the technology is essentially at hand. For deepwater deposits however, there are significant constraints to development as follows:

1. Because offshore marine mining is an emerging industry for which technology is only partially developed, an immense amount of initial capital is required for the research, survey and technical development that must precede a mining and processing operation.

2. Marine mining presents a variety of challenges to the design, development, and operation of marine mining systems. Development and capital costs for vessels and marine systems can be high. Profitability of offshore mining ventures will begin only when safe and efficient mining systems can be built and operated at reasonable costs.

3. All known cobalt-rich manganese crust deposits occur in deep waters, beyond the range of present technological capability. Before mining equipment can be designed, more technical and engineering data must be developed. As part of the final EIS produced for MMS by the joint Federal-State Task Force, a mining development scenario was formulated to consider the technical details of mining, transportation and metallurgical processing. Although the technologies for transporting and processing are fairly well developed, those for mining are not. Nothing equivalent to manganese crusts has ever been mined under water (Morgan et al 1988).

4. A relatively detailed mining development scenario which describes and evaluates the various subsystems required to

mine crusts has been prepared as part of the EIS. A number of approaches are possible for each subsystem, but the basic tasks are the same. Subsystems would be required to fragment, collect and crush crust and probably to partially separate crust from substrate before conveying ore to the surface. Manganese crust mining is uneconomical with existing technology (Clark 1990).

5. The future of deep-sea mining may be determined by major technological breakthroughs. Among the more significant of these would be technologies involving robotics and artificial intelligence, computer-assisted mining tools, new lighter and stronger materials and *in situ* processing (Clark 1990). Although future technologies hold great promise for deep-sea mining activities, such mining operations are still a high-risk venture. Yet, this is a field that will generate innovative research and technology-transfer opportunities.

Nearshore mining, the most near-term mining venture for Hawaii, is feasible with current technology. Dredge-mining technology has been used extensively for harbor and channel dredging.

The dredge is the standard technology for excavating unconsolidated materials from the seafloor. Existing or modified dredge-mining systems could place many nearshore deposits in the range of technical exploitability (U.S. Congress 1987). The main dredging techniques that can be used are bucketline, suction and grab. For sand mining, suction devices are most widely used for recovery operations. Suction dredges, using an airlift system, or suction probes, using a jet pump, have successfully been used to recover sand deposits. Field tests conducted near Keauhou Bay in 1974 demonstrated the feasibility of using the jet pump (Discussion of the economic and engineering aspects of the Submarine Sand Recovery System can be found in Casciano 1973a: 1976).

Research Activities

The Marine Minerals Technology Center (MMTC) was established by Congress in 1988 as a generic research center within the Mineral Institutes Program at the U.S. Bureau of Mines, Department of the Interior (Cruickshank and Woolsey 1989). The center was created to facilitate the development of a domestic technological capability needed for the efficient and environmentally compatible exploitation of the mineral resources. MMTC also functions as a training center and an information and reference center, particularly with regard to the transfer of technological developments to industry and the public.

MMTC is composed of separate divisions for nearshore and deep ocean research. The Ocean Basins Division (OBD) is administered by the Center for Ocean Resources Technology (CORT) at the University of Hawaii with operational facilities located at the James K.K. Look Laboratory of Ocean Engineering in Honolulu.

The research programs at OBD complement the ongoing marine minerals activities at the Hawaii Institute of Geophysics (HIG), Hawaii Undersea Research Laboratory (HURL) and East-West Center Resources Systems Institute (EWC/RSI). A number of research projects are underway, including an investigation of alternative mining targets associated with manganese crusts that have provided useful information on by-products such as platinum and phosphorite. Much of that research is cofunded by DBED, University of Hawaii Sea Grant College Program, and U.S. Minerals Management Service (Cruickshank and Woolsey 1989; Olson and Cruickshank 1989).

Studies to determine potential nearshore sand resources are being conducted by MMTC. MMTC, together with the Department of Ocean Engineering, University of Hawaii, has resumed a long-dormant research effort to identify Hawaii's nearshore sand deposits.

A considerable amount of research has been conducted to identify, map and determine the volume and type of sand in nearshore areas (Dollar 1979). Some of the earliest studies on the utilization of offshore sand deposits were done in the 1960s by the University of Hawaii. Two components of these early studies involved an inventory of offshore sand deposits throughout the Hawaiian Islands, while another part involved the feasibility of exploiting these deposits (Casciano and Palmer 1969). The sand inventory and recovery projects are now being continued at MMTC under the Sand for Hawaiian Beaches Study.

Public Awareness

A most important issue for marine mining in Hawaii is the need to dispel the public perception that mining is by definition an unnecessary activity, engaged in only for profit , and highly destructive to the environment. There is a need for factual information to better inform people so they can understand the potential economic importance of marine minerals mining, as well as its potential impacts. A major effort has been made to establish a solid base for public information on the possibilities associated with a marine minerals industry in Hawaii in this regard:

1. Since 1972, the State has produced a lengthy series of publications assessing the potential impacts and establishing environmental baseline conditions (See Note1). In 1987 for example, the State published three documents that addressed various aspects of offshore marine mining for manganese crusts. One volume envisioned a mining development scenario for crusts and another assessed infrastructure requirements. The third, a draft environmental impact statement, analyzed the environmental impacts of such an industry.

2. During a four-year period, a series of well-attended public hearings and meetings were held on the potential of developing a marine minerals industry in Hawaii. These meetings provided the public with an opportunity to identify a variety of concerns that were addressed in the final EIS.

3. In October 1990, the final EIS was released for the Proposed Marine Mineral Lease Sale: Exclusive Economic Zone Adjacent to Hawaii and Johnston Island, jointly prepared and published

by the State and DOI's Minerals Management Service. The purpose of the proposed action is to offer for lease portions of the seafloor in the EEZ for mine site delineation, development and production of cobalt-rich manganese crust minerals. No date has been set for a lease sale. Three alternatives to the proposed action also were assessed in the EIS. They were to: 1) modify the proposed lease sale by omitting certain deposit sites in the southwest portion of the EEZ adjacent to Hawaii; 2) delay the sale for five years; and 3) permit no lease sales.

Nearshore sand mining activities in the early 1970s resulted in the publication of a environmental statement for a proposed sand mining test at Keauhou Bay. A final EIS was released in 1974 (Casciano 1973b). The EIS analyzed the proposed action of the full-scale, long-endurance field test of the prototype of an unique system for mining bottom sand. Alternatives to the proposed action also were considered.

Environmental Considerations

Little direct experience exists with commercial marine mining in terms of estimating the potential for environmental harm. Even dredging operations or recovery of sand for beach enhancement, which has been studied in some detail, are sporadic operations that do not reflect the impacts that could result from long-term operations. Careful consideration in the proposed actions was the goal of the EISs for sand recovery projects and mining of manganese crusts.

Exploration

Offshore Resources: Exploration, which will precede actual mining, is necessary to design and refine mining systems as well as provide information in response to technical and environmental considerations. During exploration and exploitation, the effects on the surrounding ocean environment would need to be monitored.

In order to provide a baseline characterization of a representative seamount, a detailed site-specific survey was undertaken. Cross Seamount, 170 miles south of Honolulu, was selected because it is an environmentally sensitive area; it supports a fishery and at the same time, it has well-developed manganese crusts. Data collected from this survey is presented in the final EIS to provide a realistic assessment of a Hawaiian seamount benthic environment.

The proposed action would offer for lease portions of the 2.2 million square kilometers within the EEZ adjacent to Hawaii and Johnston Island. Within this area, only the seafloor in water depths between 800 and 2,400 meters is proposed for inclusion in the initial lease area. This included area (termed "permissive area" in the EIS) is approximately 1.2 percent of the entire lease sale area (DOI 1990).

The scope of the EIS is limited by the overall lack of data on manganese crusts in general. These limitations result because only limited research has been completed within the study area. A test mine site is therefore needed, to complete further analysis of the commercial potential and test new technology. Exploration may help to respond to technical and environmental considerations. The effects on the surrounding ocean environment would be monitored before, during, and after exploration and exploitation operations.

Nearshore Resources: The environmental impacts of nearshore exploration can be preliminarily assessed from the EIS conducted at Keauhou. Environmental surveys conducted before, during and after a two-month field test of the offshore sand mining and delivery system demonstrated that the generation of turbidity and suspended sediment attributed to sand recovery operations was negligible and caused no adverse impact to nearby coral reefs or other marine life (UH 1977).

Mining

Offshore Resources: The manganese crust EIS mining analysis scenario represents the most likely description of the development activities possible with available information and current expertise in the relevant technical disciplines (DOI 1990).

The area to be mined in one year could be as small as one square mile. Mining would not be permitted within 50 miles of any Hawaiian Island. Extensive recreational and commercial fishing in these areas, the existence of precious corals, and the proximity to heavily used shorelines all pose potential multiple-use conflicts for such development. In addition, the tourism industry would not be adversely impacted by mining operations. The most promising sites are in the EEZ around Johnston Island, more than 700 miles from Hawaii. Marine mining impacts depend on a variety of factors, such as size and location of operations, dynamics of the ocean operations area, and physical setting of the minerals themselves.

The mining system would include a crust pick-up mechanism which dislodges the crust from its substrate, crushes the recovered material and transfers it onto a lift pipe to the mining ship. The most significant impact concerns from this operation are associated with the suspended particulate matter produced near the seafloor and at the surface lift-pipe overflow. A potential mitigation measure discussed in the EIS would require the subsurface discharge of these suspended particles to whatever depth necessary if any significant adverse impacts are identified through testing activities.

Generally, very low and low impacts are predicted for the activities at the mine site except in the case of mine-site benthic fauna. Benthic fauna in the path of the mining device would suffer a high impact while fauna in the range of sedimentation (particles suspended by the mining operation) would suffer low to moderate impacts (DOI 1990)

Nearshore Resources: Physical disturbance from dredge-mining operations would consist of removing a layer of the seafloor, conveying it to the surface and reinjecting the material into a barge for transport. The mining operation would generate a transient "plume" of sediment that would affect the surface, water column and adjacent areas of the oceanfloor for a period of time.

Benthic communities will be disturbed in areas mined. Mollusks inhabiting the sand and echinoderms migrating across the sand deposits would be affected. These impacts can be mitigated or largely avoided by conducting adequate field surveys before selecting a site (UH 1977). Recolonization is expected to take place quickly in high-energy, shallow water communities (U.S. Congress 1987).

An important concern is the impact on the beach itself as a result of nearshore sand mining. The removal of sand from any part of the littoral sand budget system can affect all other parts (for further discussion of the littoral sand budget, see Beaches and Coastal Erosion Technical Paper). Offshore deposits of sand, in quantities suitable for mining operations, most likely would be found 3,000 to 6,000 feet offshore (Griffin 1990). These sand resources lie outside of the littoral sand budget and, therefore, are already "lost" to the system, i.e., the sand would neither be redeposited onto the beach over time nor would its removal adversely affect the beach.

Transportation

Offshore Resources: The recovered ore would be transferred to bulk cargo vessels in a slurry, transported to docking facilities near the processing plant site, and then transferred again in slurry to the plant itself. Of major concern during these activities are accidental discharges of ore and the impacts on vessel lanes, harbor traffic and docking space (see Harbors Technical Paper).

Nearshore Resources: Sand transported to the surface is in the form of a slurry consisting of approximately 75 percent water and 25 percent sand. The slurry is placed either in a barge, which transports the sand to the shore, or it is piped to shore for placement in a deposition basin. Either method of transport could result in an accidental discharge, resulting in siltation being deposited on adjacent marine biota (Casciano 1973b).

Processing

Offshore Resources: Onshore processing of mineral crusts involves other kinds of effects apart from those associated with mining. A processing facility within the State could play a significant role in diversifying the economy. If it is not environmentally or socially acceptable, or if it cannot become so without considerable costs to other areas of the economy such as tourism, however, processing might not provide net benefits to the State. The resolution of the impacts of this final phase are integrally linked to the economics of the industry and the impacts on the environment.

To allow analysis of the various possible impacts to processing plant sites in Hawaii, three general locations are examined in the EIS. They were selected to embrace a range of environmental analyses and include a site representing the wet side of an Island (Puna), the dry side of an Island (Kohala) and an industrial park setting (Ewa). These sites do not represent land-use alternatives favored by Federal, State, or County governments or any individual landowners (DOI 1990). Processors may select sites outside Hawaii. The key potential impacts at the process plant sites are those of land-use and air quality (ibid).

RECOMMENDATIONS

Objective

Explore the establishment of a marine minerals industry which is economically beneficial, environmentally sound, and socially acceptable to the people of Hawaii.

Policy A

Assert the State's interest in a full partnership with the Federal government in managing marine minerals activities, including the equitable sharing of any revenues derived from the mining of manganese crusts.

Implementing Actions:

DBED, in cooperation with OSP, should:

1. Continue to encourage Hawaii's congressional delegation to amend the OCSLA or create new minerals legislation giving the State equitable revenue-sharing benefits from EEZ marine mining and leasing activities. Such legislation should grant coastal states a meaningful role in offshore mining decision-making without compromising other interests of the State of Hawaii.

2. Continue to pursue full partnership with the Federal government by using the successful implementation of the Federal/State Joint Planning Arrangement as partial justification for joint management of Hawaii's EEZ.

Policy B

Encourage and support appropriate research activities that will help to determine what types of marine minerals industry can be established within Hawaii's EEZ without incurring unacceptable environmental or social costs.

Implementing Actions:

DBED, in cooperation with OSP, DLNR, DOH, UH and appropriate Federal agencies, should:

1. Provide for monitoring the environmental effects of offshore marine minerals development, mining and processing on marine biota and the ocean/atmospheric system by conducting studies of the ocean environment before, during and after the undertaking of these activities through the Federal/State Joint Planning Arrangement. Because of the newness of the technology and lack of comprehensive data regarding the environmental effects of such mining, consideration should be given to establishing an experimental industry/Federal/State mine site prior to embarking on large-scale development activities. Information gained from the experimental site should be used in developing a permanent regulatory regime.

DBED should:

2. Coordinate any onshore activities with DOT and other appropriate State and County agencies in anticipation of any infrastructure needs relating to processing or transshipment of marine minerals.

DLNR, in cooperation with UH and DOH, should:

3. Monitor the environmental effects of nearshore exploratory and sand recovery projects on marine biota by conducting studies on the ocean environment before, during and after the undertaking of these activities.

Policy C

Foster public awareness and facilitate informed public input regarding the development of marine minerals mining, processing and related efforts in the State.

Implementing Actions:

DBED should:

1. Ensure that the public is informed as to the efforts taken by the State to explore developing an offshore marine minerals industry and onshore support network.

DLNR should:

2. Follow a similar action to keep the public informed as to the efforts taken to address the potential development of nearshore sand recovery.

DBED and DLNR should:

3. Achieve these goals by providing informational materials and conducting public workshops.

Policy D

Promote appropriate environmentally sound and socially acceptable private-sector development in the area of marine mining, processing and related efforts in the State.

Implementing Actions:

DBED should:

1. Consider the use of economic and other incentives that would encourage exploration of an economically viable, environmentally sound, and socially acceptable marine minerals industry in Hawaii.

2. Review the State and Federal regulatory systems as they apply to offshore minerals mining to determine what, if any, unnecessary impediments exist to developing a viable industry.

Policy E

Establish local expertise in marine mining and make industry aware of Hawaii as a marine minerals center.

Implementing Actions:

DBED should:

1. Identify existing experts and help to develop new local expertise in offshore minerals and mining by running seminars on scientific findings and technology developments related to marine minerals.

2. Establish Hawaii as a center for coordination of marine minerals development in the Pacific and as a site for research and development for technology transfer applications.

NOTES

1. For publications representative of the State's efforts to increase public awareness regarding marine minerals development see: The feasibility and potential impact of manganese nodule processing in Hawaii. Honolulu, February 1978; Feasibility and potential impact of manganese nodule processing in the Puna and Kohala districts of Hawaii, DPED and U.S. Office of Ocean Minerals and Energy, NOAA, 1981, Honolulu; Marine mining: a new beginning, Conference Proceedings, DPED, July 1982, Hilo, Peter B. Humphey (ed.); Potential fiscal impacts of manganese nodule processing in the Puna and Kohala Districts of Hawaii, D. M. Blood and J. R. Davidson, UH-Sea Grant, May 1984, Honolulu; A baseline study of soil geochemistry in selected areas on the island of Hawaii, J. B. Halbig, *et al*, 1985, Honolulu; A baseline study of ground water geochemistry in the Kawaihae and Hilo areas on the island of Hawaii, J. B. Halbig, *et al.*, 1986, Honolulu; A baseline study of the geochemistry and sedimentology of nearshore marine sediments in selected areas off the island of Hawaii, W. C. Dudley, 1986, Honolulu; Infrastructure requirements for a marine minerals processing industry, R. W. Jenkins and F. C. Brown, 1987, Honolulu; The predicted effects of dissolved manganese in the photic zone, C. W. Rice, 1987, Honolulu. [DBED was formerly the Department of Planning and Economic Development — DPED.]

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APPENDIX I
ACRONYMS AND ABBREVIATIONS

FEDERAL

COE	(Army) Corps of Engineers
CZMA	Coastal Zone Management Act
DOC	Department of Commerce
DOE	Department of Energy
DOI	Department of Interior
EDA	Economic Development Administration (DOC)
EPA	Environmental Protection Agency
FCMA	Fisheries Conservation and Management Act
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FMP	Fisheries Management Plan
FWS	Fish and Wildlife Service (DOI)
IRS	Internal Revenue Service
ITA	International Trade Administration (DOC)
MAFAC	Marine Fisheries Advisory Committee (NOAA)
MMS	Minerals Management Service (DOI)
MPRSA	Marine Protection, Research and Sanctuaries Act
NERR	National Estuarine Research Reserve (NOAA)
NMFS	National Marine Fisheries Service (NOAA)
NMS	National Marine Sanctuary (NOAA)
NOAA	National Oceanic and Atmospheric Administration (DOC)
NPDES	National Pollution Discharge Elimination System (EPA)
NPS	National Park Service (DOI)
NSF	National Science Foundation
NWR	National Wildlife Refuge (DOI)
OCRM	Office of Coastal Resources Management (NOAA)
OCSLA	Outer Continental Shelf Lands Act
OSIM	Office of Strategic and International Minerals (MMS)
OTA	Office of Technology Assessment (U. S. Congress)
PFDF	Pacific Fisheries Development Foundation
PURPA	Public Utilities Regulatory Policies Act
SBA	Small Business Administration
SBIR	Small Business Innovative Research Grants
SID	Secretarial Issue Document
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USN	U.S. Navy
WESTPAC	Western Pacific Regional Fishery Management Council (NOAA)

STATE

ADP	Aquaculture Development Program (DLNR)
AFRC	Anuenue Fisheries Research Center (DLNR)
ARLF	Aquaculture Revolving Loan Fund (DOA)
BLNR	Board of Land and Natural Resources (DLNR)
CDUA	Conservation District Use Application (DLNR)
CORT	Center for Ocean Resources Technology (UH)
CZM	Coastal Zone Management Program (OSP)
DAGS	Department of Accounting and General Services
DAR	Division of Aquatic Resources (DLNR)
DB&F	Department of Budget and Finance
DBED	Department of Business, Economic Development &Tourism
DCCA	Department of Commerce and Consumer Affairs
DLNR	Department of Land and Natural Resources
DOA	Department of Agriculture
DOCARE	Division of Conservation and Resources Enforcement (DLNR)
DOE	Department of Education
DOH	Department of Health
DOT	Department of Transportation
FMA	Fishery Management Area (DLNR)
HAR	Hawaii Administrative Rules
HAAC	Hawaii Aquaculture Advisory Council
HCDA	Hawaii Community Development Authority (DBED)
HEER	Hazard Evaluation and Emergency Response Office (DOH)
HEIS	Hawaii Environmental Impact Statement Law (HRS)
HIG	Hawaii Institute of Geophysics (UH)
HIMB	Hawaii Institute of Marine Biology (UH)
HNEI	Hawaii Natural Energy Institute (UH)
HOC	Hawaii Ocean Center
HOST	Hawaii Ocean Science and Technology Park (NELHA)
HRS	Hawaii Revised Statutes
HTDC	High Technology Development Corporation (DBED)
HURL	Hawaii Undersea Research Laboratory (UH)
JIMAR	Joint Institute for Marine and Atmospheric Research (UH)
LUC	Land Use Commission
MHI-MRI	Main Hawaiian Islands Marine Resources Investigation (DLNR)
MLCD	Marine Life Conservation District (DLNR)
MMTC	Marine Minerals Technology Center (UH)
MRTC	Mariculture Research and Training Center (UH)
NARS	Natural Area Reserve System (DLNR)
NELH	Natural Energy Laboratory of Hawaii (NELHA)
NELHA	Natural Energy Laboratory of Hawaii Authority (DBED)
NWHI	Northwestern Hawaiian Islands
OBD	Ocean Basins Division (MMTC)
OMPO	Oahu Metropolitan Planning Organization
OEQC	Office of Environmental Quality Control (DOH)
ORB	Ocean Resources Branch (DBED)
ORMA	Ocean Recreation Management Areas (DOT)
OSP	Office of State Planning
PUC	Public Utilities Commission (DCCA)
SG	Sea Grant College Program (UH)
SGES	Sea Grant Extension Service (UH)
SCORP	State (of Hawaii) Comprehensive Outdoor Recreation Plan
UH	University of Hawaii
WQS	Water Quality Standards (DOH)

COUNTY

C&C	City and County
DLU	Department of Land Utilization (City & County of Honolulu)
KARRP	Kealia Aquatech and Renewable Resources Park (Maui)
PUC	Public Utilities Commission
SMA	Special Management Area

OTHER

ACA	American Canoe Association, Hawaii Division
AFPI	American Flag Pacific Islands
CC	Coordinating Commitee (JPA)
CSC	Cooperative Steering Committee (JPA)
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EWC/EAPI	East-West Center/Environment and Policy Institute
EWC/RSI	East-West Center/Resource Systems Institute
FADs	Fish Aggregating Devices
GIS	Geographic Information System
HDWC	Hawaii Deep-Water Cable
HECO	Hawaiian Electric Company
HLW	High Level Wastes
IUCN	Int'l. Union for Conservation of Nature and Natural Resources
JPA	Federal/State Joint Planning Arrangement (Marine Minerals)
LLW	Low Level Wastes
MSY	Maximum Sustainable Yield
NPS	Nonpoint Source Pollution
OI	Oceanic Institute
OTEC	Ocean Thermal Energy Conversion
PICHTR	Pacific International Center for High Technology Research
PIRO	Petroleum Industry Response Organization
R&D	Research and Development
RFP	Request for Proposal
TORCH	The Ocean Recreation Council of Hawaii

APPENDIX II
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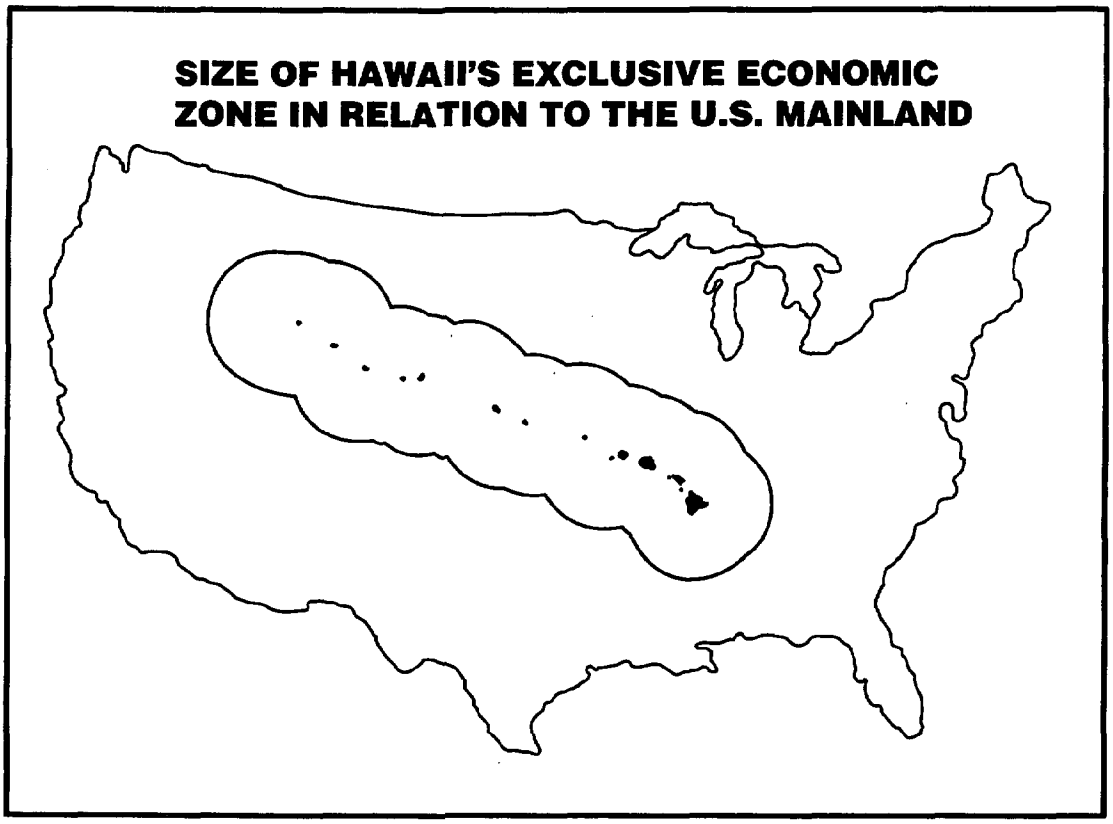
APPENDIX III
HAWAII'S EXCLUSIVE ECONOMIC ZONE



The Hawaiian archipelago extends 1,523 miles NW to SE and is surrounded by an Exclusive Economic Zone (EEZ) encompassing an area of 922,967 square miles. With the addition of the EEZ in 1983, Hawaii became the second largest state in the nation. As can be seen by the accompanying illustration, Hawaii's vast EEZ is nearly one third the size of the contiguous United States and stretches two-thirds the distance between Seattle, Washington and Charleston, South Carolina. As stated in the Hawaii Ocean Resources Management Plan, Hawaii's current challenge is to acknowledge and fully comprehend the enormity of its ocean and coastal resources, and to develop an effective management regime to care for them.

APPENDIX IV
STATE OCEAN PROGRAMS

The matricies in Appendix IV A, B and C are based on survey data provided by the individual departments of the State administration. For the most part, the departments defined for themselves: (1) what they considered to be ocean and marine programs, (2) how they categorized their programmatic activities, and (3) how they allocated staff and programmatic resources within these categories. Responsibility for accuracy and completeness of this information lies largely with the respective agencies and programs. In some cases it was difficult to discern ocean and marine components from overall programmatic responsibilities; these cases are noted and briefly explained. For these latter reasons in particular, the level of precision is low and the estimates are conservative. This information should be viewed only as a first approximation.

Note: FTE positions as reflected in Appendix IVC represent only full-time equivalent civil service positions. Counts of other positions (exempt or contractual) are not provided. However, the monies for these other positions are included under operating funds.

APPENDIX IVA STATE OCEAN PROGRAMS - by Activity and Government Agency

REGULATED ACTIVITY	DBED	DLNR	DOA	DOE	DOH	DOT	DSP	FED	COUNTY
Recreation									
BOATING									
• Statewide boat launching facilities program • Statewide improvements and boating facilities						Harbors Division — Boating and Engineering Branches			
• Boating Safety (marine casualty and investigation)						Office of Safety and Enforcement			
Harbors									
COMMERCIAL HARBORS									
• Harbor facilites improvements and expansions • Statewide harbor planning						Harbors Division— Engineering Branch			
• Harbor Safety (marine casualty and investigation)						Office of Safety and Enforcement			
FERRIES/MASS TRANSIT									
• Molokai-Maui commuter ferry	Industry Promotion Division — Ocean Resources Branch								
• Intra-island ferry system						Harbors Division — Engineering Branch			
Fisheries									
FISHING VESSEL LOANS	Financial Services Branch								
SEAFOOD PROMOTIONS	Industry Promotion Division — Ocean Resources Branch		Marketing Division — Market Development Branch						
FISHERIES RESOURCE DEVELOPMENT • Artificial habitat for bottomfish • Fish catch statistics		Aquatic Resources Division— Administration						FWS WESTPAC NMFS PFDF	

APPENDIX IVA STATE OCEAN PROGRAMS - by Activity and Government Agency

REGULATED ACTIVITY	OBED	DLNR	DOA	DOE	DOH	DOT	DSP	FED	COUNTY
• Recreational fishing rules • Mahimahi culture • Artificial reef enhancement		Recreational Fisheries Branch							
• Buoys/trolling alleys • Fish aggregating devices • Fish toxicity tests • New fishing grounds survey • Deepwater habitat enhancement • Automated fisheries information		Commercial Fisheries and Aquaculture Branch							
• Main Hawaiian Islands marine resources investigation • Information and Education		Aquatic Resources and Environment Protection Branch							
COMMERCIAL FISHERIES INFRASTRUCTURE DEVELOPMENT						Harbors Division			
SEAFOOD INSPECTIONS					Environ-mental Health Services Division — Food and Drug Branch				
Marine Ecosystem Protection									
WILDLIFE and HABITAT MANAGEMENT • Wildlife sanctuaries • Annual sea-bird surveys • Annual waterbird surveys		Division of Forestry & Wildlife						FWS NMFS OCRM	

APPENDIX IVA STATE OCEAN PROGRAMS - by Activity and Government Agency

REGULATED ACTIVITY	OBED	DLNR	DOA	DOE	DOH	DOT	OSP	FED	COUNTY
WILDLIFE and HABITAT MANAGEMENT *(cont.)*									
• Manage freshwater streams & resources (except fish)		Division of Water Development							
• Manage underwater parks (Hanauma Bay and Kealakekua Bay)		State Parks Division							
• Surveys of potential Marine Life Conservation Districts (MLCDs) • Monitoring MLCDs • Hawaiian sea turtle and monk seal recovery program		Aquatic Resources Division and Environmental Protection Branch							
NATURAL AREA RESERVES		Natural Area Reserve System Commission						OCRM	
REGULATORY									
• Conservation District Use Application Reviews		Conservation and Environmental Affairs Office							
• Enforcement		Conservation and Resources Enforcement Division							
Beaches and Coastal Erosion									
BEACH EROSION PROTECTION						Coastal Areas Program	Coastal Zone Management Program	OCRM	Planning Departments Parks and Recreation Departments
Waste Management									
WATER QUALITY								EPA	
• Water quality laboratory analysis					State Laboratories				
• Water quality monitoring					Environmental Management Division				

APPENDIX IVA STATE OCEAN PROGRAMS - by Activity and Government Agency

REGULATED ACTIVITY	DBED	DLNR	DOA	DOE	DOH	DOT	OSP	FED	COUNTY
Waste Management (cont.)									
HARBOR SEWER/ WASTE FACILITIES									
• Statewide commercial harbor sewer system improvements						Harbors Division-Engineering Branch			
• Statewide sewage system improvements to boating facilities						Boating Branch			
Energy									
RESOURCE DEVELOPMENT									
• Geothermal energy cable transfer system • Wave energy resource assessment	Energy Division								
• Ocean Thermal Energy Conversion	Natural Energy Laboratory of Hawaii Authority								
Aquaculture									
OTEC AQUACULTURE	Natural Energy Laboratory of Hawaii Authority								
AQUACULTURE DEVELOPMENT • Center for Applied Aquaculture at Oceanic Institute • Kauai Shrimp Pond Study • Small and large scale pond facilities • Extension services • Marine Shrimp Project • Finfish Project • Marine Biotechnology		Aquaculture Development Program							

APPENDIX IVA STATE OCEAN PROGRAMS - by Activity and Government Agency

REGULATED ACTIVITY	OBED	DLNR	DOA	DOE	DOH	DOT	OSP	FED	COUNTY
Aquaculture (cont.)									
FACILITIES INSPECTION					Environmental Management Division				
LOANS PROGRAM			Agriculture Loan Division						
PROMOTIONS and MARKETING	Industry Promotion Division — Ocean Resources Branch	Aquaculture Development Program	Marketing Division — Market Development Branch						
Marine Minerals									
MARINE MINERALS INDUSTRY DEVELOPMENT	Ocean Resources Branch						Exclusive Economic Zone Program	MMS NOAA	

APPENDIX IUB SUMMARY OF STATE OCEAN PROGRAMS - by Funding and Staff Resources

AGENCY REPORTED TOTALS	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Business, Economic Development & Tourism	22 FTE $2,581,692 ***86,000***	27 3,854,372 ***161,000***	27 4,339,722 ***161,000***	125,000 **0**	2,100,000 **0**	1,213,000 **0**
Department of Land and Natural Resources	80 FTE 4,769,336 ***619,996***	80 5,190,283 ***1,042,410***	80 5,174,786 ***890,955***	0 **0**	1,000,000 **1,000,000**	4,525,000 **500,000**
Department of Agriculture	<1 175,000 ***0***	<1 80,000 ***0***	<1 80,000 ***0***	0 **0**	0 **0**	0 **0**
Department of Education	1 FTE 83,362 *0*	1 57,000 *0*	1 57,700 *0*	0 0	0 0	52,000 0
Department of Health	27.80 FTE ***9.01 FTE*** 881,952 ***1,163,673***	28.75 ***9.55*** 915,275 ***968,460***	14.15 ***.25*** 710,136 ***87,000***	0 **0**	0 **0**	0 **0**
Department of Transportation	300.50 FTE 35,333,812 ***0***	321 38,634,821 ***0***	316 41,018,313 ***0***	28,246,000 **9,273,500**	19,762,000 **18,965,000**	59,539,000 **6,313,480**
Office of State Planning	2 FTE 212,834 ***135,000***	2 66,612 ***221,000***	7 173,992 ***66,000***	3,500,000 **3,166,000**	0 **0**	19,293,000 **45,000**
REPORTED TOTALS	433 FTE $44,187,988 ***2,004,669***	460 48,798,363 ***2,492,870***	445 51,403,949 ***1,204,955***	31,871,000 **12,439,500**	22,862,000 **19,965,000**	84,622,000 **6,858,480**

bold: CIP allotments
bold italics: federal funds

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Business, Economic Development & Tourism (DBED)									
OCEAN RESOURCES BRANCH	Ch. 201			personnel:					
				4 FTE	4	4			
				$117,000	117,000	117,000			
				operating:					
				19,000	14,000	14,000			
projects/programs:									
General ocean industry				38,000	20,000	71,000			
Ocean recreation industry				40,000	35,000	0			
Marine minerals industry				83,000	90,000	88,000			
			MMS-	***86,000***	***161,000***	***161,000***			
Molokai-Maui ferry			OSIM	300,000	300,000	300,000			
Seafood promotion				176,000	170,000	190,000			
Ocean R/D promotion				70,000	142,000	144,000			
Governor's Ocean Resources Tourism Dvmt Task Force	Act 324, SLH 1988			10,000	0	0			
Hyperbaric treatment center				285,000	285,000	285,000		1,750,000	
								0	
Special project management				45,000	48,000	51,000			
Hawaii Ocean & Marine Resources Council	Ch. 228			150,000	150,000	150,000			
BUSINESS SERVICES DIVISION	Ch. 189	§15-3							
Financial Assistance Branch									
projects/programs:*									
Large fishing vessel loans program									
Small fishing vessel loans program									
HIGH TECHNOLOGY DVMT CORPORATION**	Ch. 206M	§§15-30; 15-31							
NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY* (NELHA)**	Ch. 227								
Natural Energy Laboratory of Hawaii				personnel:					
				15 FTE	20	20			
				420,000	600,000	640,000			
				operating:					
				40,000	60,000	64,000			
				facilities:					
				351,000	824,000	873,000			

** Note: Since 1986 the programs for purchase and construction of commercial fishing vessels have been temporarily suspended. Loans for renovation, maintenance and repair are still being made. The monies available in revolving funds as of December 31, 1989 are $3,094,978 for the Large Fishing Vessel Loan Program and $918,860 for the Small Fishing Vessel Loan Program.*

***Note: HTDC provides support infrastructure for ocean R&D activities.*

****Note: In 1990 HOST and NELH were combined to form NELHA*

bold: CIP allotments

bold italics: federal funds

APPENDIX IUC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY (NELHA) *(cont.)*									
Hawaii Ocean Science Technology (*HOST*) Park*				personnel: 3 FTE	3	3			
				$95,530	100.497	105.722			
				operating: 492,162	890.875	1.097.000			
Warm H_2O Pipe									830,000
Ocean Outfall								350.000	
On-Site Building									383.000
ENERGY DIVISION**	Ch. 196								
projects/programs:									
Ocean Thermal Energy Conversion (OTEC) Demi							125.000		
Wave energy resource assessment					8.000				
Geothermal Energy Cable Transfer System	Chs. 196D; 199 (DLNR)	§13-183	DOE***						
DBED Reported Total				2,581,692 ***86,000***	3,854.372 ***161,000***	4,339.722 ***161,000***	125,000 **0**	2,100.000 **0**	1,213.000 **0**

**Note: HOST was previously managed by the High Technology Development Corporation*
***Note: Energy Division funds only reflect ocean-related projects.*
****Note: Funding was primarily federal but appropriated prior to 1987.*

Department of Land and Natural Resources (DLNR)									
AQUATIC RESOURCES DIVISION (DAR)	Chs. 187A; 188; 188E;	§§13-46 to 13-54;		personnel: 8 FTE	7	7			
Administration	189; 197	13-61 to 64; 13-71 to 73; 13-83 to 93; 13-99; 15-3	DOI-FWS	$220,303 ***41,572***	$185.179 ***25,444***	$208,196 ***26,175***			
				operating: 55,987	116.052	54.492			
			DOI-FWS	***4,750***	***210,816***	***4,750***			
projects/programs:									
Artificial habitats for bottomfish				50.000	60.000	60.000			
Aquatic Enviroment and Resources Protection Branch				personnel: 9 FTE	9	9			
				$197,599	223,939	226.658			
			DOI-FWS	***35,088***	***46,091***	***49,668***			
Other projects and operating costs				182.903 ***5,405***	113.063 ***5,000***	11,415 ***0***			
projects/programs:									
Main Hwn Islands marine resources investigation				operating: 0	366,710	389,721			
			DOI-FWS	***0***	***210,000***	***210,000***			
Marine Life Conservation Districts*	Ch. 190	§§13-28; 13-36							

**Note: Monies included under operating expenses and personnel of these multiple DAR programs.*

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	OPERATING BUDGET FY 90	OPERATING BUDGET FY 91	CIP APPROPRIATIONS 1987	CIP APPROPRIATIONS 1988	CIP APPROPRIATIONS 1989
Aquatic Enviroment and Resources Protection Branch (cont.)									
Hawaiian sea turtle and monk seal recovery*									
Information and Education Unit				personnel:					
				7 FTE	8	8			
				$106,955	126,168	135,053			
			DOI-FWS	***0***	***39,954***	***43,054***			
				operating:					
				61,086	128,104	67,200			
			DOI-FWS	***0***	***0***	***6,995***			
Commercial Fisheries and Aquaculture Branch									
Commercial Fisheries Program				personnel:					
				4 FTE	4	4			
				$99,953	121,042	107,980			
			DOI-FWS	***5,940***	***5,104***	***5,500***			
Other projects and operating costs				178,789	46,461	18,651			
projects/programs:									
Fish Catch Report booklets				14,075	14,807	15,577			
Fish aggregating devices, buoys/trolling alleys				76,000	76,000	76,000			
			DOI-FWS	***125,000***	***125,000***	***125,000***			
Fish toxicity tests				50,000	31,689	41,123			
New fishing grounds survey				82,300	45,300	78,300			
Deepwater habitat enhancement				40,000	30,000	47,000			
Automated fisheries information				0	262,811	130,242			
Aquaculture Program (not part of ADP)				personnel:					
				7 FTE	7	7			
				$338,513	346,712	382,331			
				operating:					
				157,712	173,409	309,150			
			DOI-FWS	***35,000***	***0***	***0***			
Recreational Fisheries Branch									
Sport Fishing Program**				personnel:					
				8	8	8			
				$120,608	85,424	109,293			
			DOI-FWS	***138,132***	***152,691***	***164,583***			
Other projects and operating costs				235,129	146,144	250,369			
			DOI-FWS	***173,676***	***195,067***	***176,019***			
projects/programs:									
Mahimahi culture				$22,096	25,000	25,000			
Artificial reef enhancement				5,875	12,500	12,500			
			DOI-FWS	***17,625***	***37,500***	***37,500***			
NATURAL AREA RESERVE SYSTEM COMMISSION	Ch. 195	§§13-208 to 13-209			personnel: $18,200				
projects/programs:									
Ahii-Kinau Reserve					0				
Waimanu National					31,800				
Estuarine Research Reserve			NOAA		***50,000***				

**Note: Monies included under operating expenses and personnel of these multiple DAR programs.*

***Note: Includes funding for saltwater and freshwater fish. Proportions vary from year-to-year.*

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	OPERATING BUDGET FY 90	OPERATING BUDGET FY 91	CIP APPROPRIATIONS 1987	CIP APPROPRIATIONS 1988	CIP APPROPRIATIONS 1989
STATE PARKS DIVISION	Ch. 198D								
projects/programs:									
Manage underwater parks				*no funds allocated*					
CONSERVATION AND ENVIRONMENTAL AFFAIRS OFFICE	198; 205	13-121; 13-183; 15-15							
projects/programs:*									
Conservation district use application reviews									
FORESTRY AND WILDLIFE DIVISION	Chs. 183D; 195D; 197	§13-4; 13-121 to 13-125		personnel:					
				1 FTE	1	1			
				$2,003	2,123	2,229			
			DOI-FWS	***6,008***	***6,368***	***6,686***			
projects/programs:									
Wildlife sanctuaries (marine components)				6,475	6,800	7,150			
			DOI-FWS	***19,425***	***20,400***	***21,450***			
Annual seabird surveys				3,075	3,225	3,375			
			DOI-FWS	***9,225***	***9,675***	***10,125***			
Annual waterbird surveys				1,050	1,100	1,150			
			DOI-FWS	***3,150***	***3,300***	***3,450***			
AQUACULTURE DEVELOPMENT PROGRAM	Chs. 189G; 187A			personnel:					
				10 FTE	10	10			
				$262,191	264,422	264,422			
				operating:					
				55,511	59,028	61,899			
			svcs on fee projects:						
				643,509	561,651	561,651			
projects/programs:									
Center for Applied Aquaculture at the Oceanic Institute	Act 360, SLH 1988							1,000,000	4,000,000
								1,000,000	**0**
Kauai Shrimp Pond Study	Act 314, SLH 1989								25,000
									0
Large-scale pond facilities	Act 316, SLH 1989, A-11								500,000
									500,000
Small-scale pond aquaculture				36,870	34,985	34,985			
Extension and development activities				152,632	218,910	218,910			
Marine Shrimp Project				220,586	73,960	73,960			
Finfish Project				183,179	158,769	158,769			
Marine Biotechnology				46,271	41,649	41,649			
DIVISION OF CONSERVATION AND RESOURCES ENFORCEMENT**	Ch. 199			personnel:					
				26 FTE	26	26			
				$698,940	780,450	785,730			
				operating:					
				161,161	196,697	202,656			
DLNR Reported Total				$4,769,336	5,190,283	5,174,786	0	1,000,000	4,525,000
				619,996	***1,142,410***	***890,955***	**0**	**1,000,000**	**500,000**

** Note: "Ocean" and "coastal" components are not differentiated from "land" in record-keeping.*

***Note: Division covers both terrestrial and marine responsibilities. The figures provided here represent one-third of the total personnel and operating costs and are a rough estimate for ocean resources enforcement.*

APPENDIX IUC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Agriculture (DOA)									
AGRICULTURE LOANS DIVISION									
projects/programs:									
Aquaculture loan program	Ch. 219	§4-9		personnel: <1	<1	<1			
				operating: $175,000	80,000	80,000			
MARKETING DIVISION - MARKET DEVELOPMENT BRANCH									
projects/programs:*									
Seafood and aquaculture promotion									
PLANT INDUSTRY DIVISION - PLANT QUARANTINE BRANCH									
projects/programs:**									
Marine plant and animal species inspections									
DOA Reported Total				$175,000 ***0***	80,000 ***0***	80,000 ***0***	0 **0**	0 **0**	0 0
Department of Education (DOE)									
OFFICE OF INSTRUCTIONAL SERVICES - MARINE EDUCATION PROGRAMS				personnel: 1 FTE $38,282	1 39,000	1 39,700			
				operating: 37,206	10,000	10,000			
projects/programs:									
Marine Symposium				7,874	8,000	8,000			
Marine Science Learning Center									
Two aquaculture ponds - Waianae									52,000 **0**
DOE Reported Total				$83,362 ***0***	57,000 ***0***	57,700 ***0***	0 **0**	0 **0**	52,000 0

** Note: Not budgeted for specifically but done cooperatively with DBED (ORB) and DLNR (ADP).*

***Note: Marine component is undifferentiated in quarantine inspections.*

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Health (DOH)									
ENVIRONMENTAL HEALTH ADMINISTRATION									
Environmental Management Division	Chs. 128D 174C; 180C; 342B; 344	§§11-59; 11-60							
projects/programs:									
Water quality monitoring program	Chs. 342D;	§§11-54;		personnel:					
	342H; 342J	11-55; 11-58	EPA	*.92 FTE*	*.92*				
		11-61; 11-68		*$43,350*	*40,707*				
				planning:					
			EPA	*2.6 FTE*	*3.3*	2			
				$419,673	*352,737*	68,250			
				permitting:					
				6.6 FTE	6.6				
				$203,002	218,985				
			EPA	*2.9 FTE*	*3*				
				$194,825	*199,002*				
				monitoring and analysis:					
				10.75 FTE	12	5			
				$372,521	386,069	479,729			
			EPA	*.75 FTE*	*.5*				
				$222,977	*178,903*				
				enforcement:					
				3.3 FTE	3				
				$152,165	148,310				
			EPA	*1 FTE*	*1*				
				$82,605	*40,103*				
				training and technical assistance:					
			EPA	*.125 FTE*	*.083*				
				$30,890	*30,120*				
				public participation and education:					
			EPA	*.71 FTE*	*.75*	*.25*			
				$105,062	*40,590*				
FOOD & DRUG BRANCH									
projects/programs:									
Seafood inspections*	Chs. 321; 328	§§11-29; 11-34; 11-35							
STATE LABORATORIES									
projects/programs:									
Water quality laboratory analysis	Chs. 342D, 342H, 342J	§§11-54; 11-55; 11-58 11-61; 11-68		personnel:					
				5 FTE	5	5			
				$120,000	125,000	125,000			
				operating:					
				30,000	32,000	32,000			

Note: Costs and personnel for seafood inspections are lumped among all food inspections.

APPENDIX IUC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Health(DOH) (cont.)									
SANITATION BRANCH									
projects/programs:*									
Aquaculture facilities inspections									
HEALTH PROMOTION AND DISEASE PREVENTION DIVISION									
projects/programs:									
Honolulu aquatic safety intervention program				personnel: .15 FTE $4,264	.15 4,911	.15 5,157			
			Centers for Disease Control	operating: 2 FTE ***$64,291***	2 ***86,298***	2 ***87,000***			
OFFICE OF ENVIRONMENTAL QUALITY CONTROL	Ch. 341	§11-201							
projects/programs:**									
Environmental impact statements	Ch. 343	§§11-200							
DOH Total				$881,952 ***1,163,673***	915,275 ***968,460***	710,136 ***87,000***	0 **0**	0 **0**	0 **0**
Department of Transportation (DOT)	Chs. 190D; 277; 279								
COMMERCIAL HARBORS	Ch. 266	§§19-61 to 19-65; 19-81 to 85		personnel: 229 FTE $6,280,391	235 6,199,376	236 6,199,376			
				other: 23,571,930	25,626,042	27,576,112			
				equipment: 59,902	507,730	268,357			
				vehicle: 60,792	163,320	148,750			
projects/programs:									
Harbor facilities improvements & expansions							Honolulu Harbor:		
							80,000		110,000
							80,000		**60,000**
							300,000		370,000
							135,000		**0**
							1,235,000		8,425,000
							225,000		**0**
							3,613,000		10,500,000
							3,012,500		**0**
							430,000		575,000
							50,000		**0**

Note: Undifferentiated among all inspection functions.
**Note: Not categorized by "ocean" and "coastal."*

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	OPERATING BUDGET FY 90	OPERATING BUDGET FY 91	CIP APPROPRIATIONS 1987	CIP APPROPRIATIONS 1988	CIP APPROPRIATIONS 1989
COMMERCIAL HARBORS									
projects/programs:									
Harbor facilities improvements & expansions (cont.)							**Barbers Point Harbor:**		
								18,100,000	3,300,000
								17,656,000	**0**
									300,000
									300,000
							Kawaihae Harbor		
							5,175,000		5,000,000
							300,000		**3,061,000**
							Hilo Harbor		
							310,000		
							310,000		
							Kahului Harbor:		
							140,000	150,000	1,200,000
							130,000	**150,000**	**566,480**
							1,100,000		500,000
							1,100,000		**0**
							Nawiliwili Harbor:		
							985,000	900,000	14,500,000
							85,000	**900,000**	**0**
							3,250,000		
							343,000		
							95,000		
							95,000		
							Kaunakakai Harbor:		
							600,000		175,000
							100,000		**25,000**
							27,000		75,000
							2,000		**25,000**
							Port Allen		
							600,000		
							600,000		
							Kewalo Basin:		
							1,490,000		
							625,000		
Misc improvements to neighbor island harbors							255,000		400,000
							155,000		**5,000**
Statewide harbor planning							135,000		300,000
							135,000		**130,000**
Intra-island ferry system	Ch. 268						1,580,000		
							98,000		
Inter-island mass transit									1,000,000
									0
Statewide harbor sewer system improvements							1,375,000		
							485,000		
Commercial fisheries pier reconstruction							500,000		
							130,000		

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
OCEAN-BASED RECREATION (BOATING)	CH. 267	§19-71 to 19-76		personnel:					
				17.0 FTE	17.0	17.0			
				54.5 FTE*	62.0*	63.0*			
				$1,593,000	1,767,000	1,784,000			
				other:					
				3,745,000	4,300,000	4,988,000			
				equipment:					
				7,500	14,133	4,950			
				vehicle:					
				0	41,410	32,135			
projects/programs:									
Statewide improvements to boating facilities							Ala Wai Harbor:		
								130,000	40,000
								92,000	**0**
								100,000	150,000
								10,000	**0**
								50,000	3,000
								5,000	**3,000**
									207,000
									0
							Heeia-Kea Harbor:		
							200,000	75,000	500,000
							200,000	**65,000**	**107,000**
							71,000		
							64,000		
							Kaulana Ramp:		
							80,000		
							0		
							Maalaea Harbor:		
							310,000		3,550,000
							25,000		**105,000**
							100,000		
							20,000		
							355,000		
							50,000		
							Kahului Launch Ramp:		
							90,000		50,000
							90,000		**50,000**
							90,000		
							90,000		
							Kaunakakai Harbor:		
							90,000		
							15,000		
							Nawiliwili Harbor:		
							115,000		
							15,000		
							200,000		
							20,000		

Note: Personnel funded through DOT Special Funds.

APPENDIX IVC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Statewide improvements to boating facilities (cont.)							**Hanalei River:**		
							90,000		
							0		
							Honokohau Harbor:		
							700,000		1,150,000
							70,000		**350,000**
							Kawaihae Harbor:		
							150,000		
							20,000		
							Keehi Lagoon:		
							430,000		550,000
							60,000		**50,000**
							1,250,000		775,000
							50,000		**200,000**
									4,884,000
									885,000
							Mala Wharf:		
							300,000	156,000	
							79,000	**11,000**	
							East-end Ramp, Molokai:		
								15,000	
								6,000	
							Miloii Pier:		
								25,000	
								25,000	
							Waikaea Harbor:		
									250,000
									250,000
							Manelele Harbor:		
									5,000
									1,000
							Other Miscellaneous Projects:		
							210,000		110,000
							70,000		**0**
Statewide boat launching facilities program									50,000
									50,000
Statewide Planning									75,000
									0
Statewide sewage system improve to boating facilities									180,000
									90,000
Statewide waste oil facilities							140,000		
							140,000		
West Maui Ocean Ocean Recreation Management Plan								11,000	
								0	

APPENDIX IUC DETAILS OF STATE OCEAN PROGRAMS - by Authority, Funding and Staff Resources

AGENCY AND ACTIVITY	HRS	ADMIN RULES	FED FUNDING AGENCY	OPERATING BUDGET FY 89	FY 90	FY 91	CIP APPROPRIATIONS 1987	1988	1989
Department of Transportation (DOT) (cont.)									
COASTAL AREAS PROGRAM	CH. 266	§19-81 to 19-85		$15,297	15,810	16,633			
projects/programs:									
Erosion control programs								Ala Wai: 50,000 **45,000**	Kuhio Beach: 280,000 **0**
SAFETY & ENFORCEMENT*									
projects/programs:									
Marine casualty and investigation program									
DOT Reported Total				$35,333,812 ***0***	38,634,821 ***0***	41,018,313 ***0***	28,246,000 **9,273,500**	19,762,000 **18,965,000**	59,539,000 **6,313,480**

Note: Monies for personnel and operating costs already are represented under both the commercial harbors and ocean-based recreation categories for DOT in this matrix.

Office of State Planning (OSP)	Ch. 225M								
Hawaii Ocean Center Program						personnel: 1 FTE $35,000 council: 10,000 operating: 55,000			
Coastal Zone Management Program*	Ch. 205A			personnel: 2 FTE $64,334	2 66,612	2 73,992			
			DOC-OCRM	operating: ***15,000***	***15,000***	***16,000***			
projects:									
beach management erosion studies			OCRM	***120,000***	***206,000***	***50,000***			
Hawaii Exclusive Economic Zone Program				$148,500	0	0			
Honolulu Waterfront Master Plan Project						personnel: 4 FTE	3,500,000 **3,166,000**		19,293,000 **45,000**
OSP Reported Total				$212,834 ***135,000***	66,612 ***221,000***	173,992 ***66,000***	3,500,000 **3,166,000**	0 **0**	19,293,000 **45,000**

Note: Figures represent "ocean-related" programs only. CZM also has landward responsibilities that are not reported here.

APPENDIX U OCEAN-RELATED COUNCILS, BOARDS and COMMITTEES (as of January 1, 1991)

COUNCILS/BOARDS/COMMITTEES	AGENCY LEAD	AGENCY ASSOCIATIONS	HRS	TITLE
Hawaii Fisheries Coordinating Council	DLNR *[Division of Aquatic Resource]*	COUNTIES PFDF WESTPAC DBED *[Industry Promotion Division - Ocean Resources Branch]* DOA *[Marketing Division - Market Development Branch]* DOT *[Commercial Harbors]* UH *[Sea Grant College Program]*	188E:	Fisheries Coordinating Council
Board of Agriculture **Advisory Committee on Pesticides**	DOA	DOH DLNR UH *[College of Tropical Agriculture and Human Resources]*	149A:	Agriculture
Hawaii Aquaculture Advisory Council	DLNR *[Aquaculture Development Program]*	OHA COUNTIES DOA *[Aquaculture Loan Division]* DOH *[Environmental Management Sanitation Branch]* DBED *[Industry Promotion Division - Ocean Resources Branch]* UH *[College of Tropical Agriculture and Human Resources]* *[Sea Grant College Program]* *[Hawaii Institute of Marine Biology]* HAWAIIAN HOMES COMMISSION	189G:	Aquaculture Advisory Council
Animal Species Advisory Commission **Aquatic Life & Wildlife Advisory Council**	DLNR *[Division of Aquatic Resources]*		197:	General Provisions Relating to Aquatic Resources & Wildlife
Commission on Water Resource Management	DLNR *[Division of Water & Land]*	DOH *[Environmental Management Division]*	174C:	State Water Code

APPENDIX U OCEAN-RELATED COUNCILS, BOARDS and COMMITTEES (as of January 1, 1991)

COUNCILS/BOARDS/COMMITTEES	AGENCY LEAD	ASSOCIATIONS	HRS	TITLE
Natural Area Reserves System Commission	DLNR	DOA DOE OSP UH	195:	Natural Area Reserves System
Environmental Council	OEQC	DOH	341:	Environmental Quality Control
Hawaii Ocean and Marine Resources Council	DBED *[Ocean Resources Branch]*	DLNR DOT OSP DOH *[Environmental Programs]* UH *School of Ocean and Earth Science and Technology]*	228:	Ocean Resources Management
Statewide Transportation Council	DOT	DBED DOA DOH OEQC OSP COUNTIES	279A:	Statewide Transportation Planning
Energy Functional Plan - Advisory Committee	DBED *[Energy Division]*	DAGS DLNR DOH DOT OMPO	196:	Energy Resources
Energy Policy Advisory Committee		DOD DOT USDOE DB & F *[Public Utilities Commission]* DCCA *[Division of Consumer Advocacy]* UH *[Hawaii Natural Energy Institute]* GOVERNOR'S COMMITTEE ON GEOTHERMAL ENERGY		
Governor's Geothermal Advisory Committee Interagency Group	DBED *[Energy Division]*		196D:	Geothermal & Cable System Development
High Technology Development Corporation Board	DBED	DB & F UH *[College of Engineering]*	206M:	High Technology Development
Natural Energy of Laboratory of Hawaii	NELHA	DBED DLNR HTDC HAWAII COUNTY UH *[Office of the President]*	227:	Natural Energy Laboratory Hawaii Authority

KEYWORD INDEX

There are two types of entries in this index. Entries without an asterisk refer to information in the narrative portion of the technical papers; entries with an asterisk refer to these papers' specific recommendations. These recommendations are also made in the Hawaii Ocean Resources Management Plan. Acronyms and abbreviations are as in Appendix I.

KEYWORD INDEX

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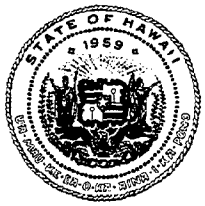

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2. Marine resources and state-Hawaii
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